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VOLUME 42 ESTABLISHED 1902 NUMBER 6

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S. D. KIRKPATRICK, Editor

JUNE, 1935

A REPUTATION TO BE SUSTAINED

WERE CHEMICAL INDUSTRY alone in the business world, the recent decision of the Supreme Court might well be the cause of exultation and selfish satisfaction. For the most part this industry's codes were unwanted. It employed no children. Its wages and hours were beyond criticism. It neither asked for nor received governmental concessions in the matter of its trade practices. In short, N.R.A. meant very little to the chemical manufacturing industry in a directly constructive way. Yet there were many things that had to be charged up against it on the other side of the ledger. Increasing costs for raw materials were perhaps less onerous than the mounting threat of regimentation and the futile philosophy of price fixing and restricted production. No other industry subscribes quite so frankly to the doctrine of the research laboratory quoted in these pages a year ago: "More goods at lower prices is the logical goal of an age of science and technology!" Now that these principles seem to have had their justification, there is need for a broader look at the problems ahead for all of industry.

The long-time effect of the Schechter decision in sustaining private enterprise is bound to be for the ultimate good of industry as well as the public. But there may be a period of uncertainty before business can start its climb to better times. The problem is to shorten that gap—not by waiting until Congress can fashion its stop-gap legislation for further bureaucratic control but by immediately laying out and following a program of cooperative, voluntary self-government. This means, at the outset, that "jungle" warfare is outlawed. The chiseler who cuts prices at the expense of labor becomes industry's Public Enemy No. 1. The sales executive who yields to unreasonable demands for drastic price cuts becomes an accomplice in the crime. Profitless sales are to be regarded as bonafide evidence that something is wrong in marketing, production or technology. No N.R.A. code could ever substitute for common sense and fair play in business conduct.

Fortunately for chemical industry and many of the process industries as well, there is no reason why self government cannot go forward immediately through the beneficial channels of strong trade associations. Few real values have been surrendered to mushroom code authorities. Readjustments should, therefore, be relatively simple. In the case of some of the smaller branches of the industry, it may be necessary and desirable to pool resources with larger and stronger associations in the field. The pattern of such an all-industry agency was cast almost twenty years ago in the Chemical Alliance which has since been revived on a larger scale to serve just such a purpose. Its president, Mr. William B. Bell, has seen and accepted the challenge: "Chemical industry has always had the reputation of maintaining fair wages and excellent working conditions and I have no doubt that this reputation will be sustained." It will if the whole industry continues of one mind and purpose in a sound program of self-government.

From an EDITORIAL Viewpoint

Tariff Revision By Dictatorship

TARIFF REVISION is in progress in Washington. This is just as true today under State Department negotiation of bilateral trade agreements as though Congress were doing the job. And according to many onlookers, the proceeding is more devastating, more dangerous, more partisanly political.

There is no doubt that a general decrease in tariffs is intended. Secretary of State Hull has evidenced clearly his plans by the completed negotiations announced with Cuba, Brazil, and others, and now with the Swedish agreement.

If industries generally like this method of tariff adjustment, they need do nothing about it. But if they do not like the changes which apply to all the world, not to single countries, they must act. And the only way to act is to persuade Congress either to curtail Presidential power or to make enough of a political commotion that the practices of the Department of State will be changed. A few more drastic reductions on commodity rates, like the list of cuts in tariffs on steel products announced late in May, are likely to stir such a political commotion. It appears to many that such protests are long overdue.

Chemical Engineering Improves Its Own Status

THERE is no more certain way than through proper education to maintain and continue to raise the standards of the chemical engineering profession. Hence by sponsoring such a conference as that on laboratory instruction recently held at Wilmington, the American Institute of Chemical Engineers is extending its leadership and influence to the very grass roots of its own future growth.

The increasing demand for chemical engineering education on the part of aggressive, farseeing youth is likely to continue. The opportunities in the process industries of the future are so great as naturally to attract young men of ability and promise. They are entitled to the best education that can be given them.

Unfortunately there is a notable shortage of men who by temperament and experience are capable of leading the faculty groups teaching chemical engineering. Demand for outstanding men in this field is nothing new. It is partly the result of the difficult task which confronts chemical engineering educators, but is also due, in part at least, to the fact that most universities and colleges have not been willing to pay as generously as they should for chemical engineering teachers.

This puts a problem squarely up to industrial executives. As the demand for chemical engineers grows, industry will have to exercise restraint in hiring the better teachers away from the universities. Industrial executives should also use their influence in order to have institutions raise the compensation of these men to levels comparable with those of industry. Then, in return, industry can expect a continued flow of new talent from the student body that in the long run will be more valuable than a few skilled men taken prematurely from the faculty.

Proper Policing Of Patent Pools

PATENT AGREEMENTS in which pooling or cross-licensing is involved would be subject to regulation if Congress enacted a bill (H.R. 4523) proposed by Dr. William I. Sirovich, chairman of the House of Representatives committee on patents. And a great many more things would seemingly come under the direct scrutiny of the Commissioner of Patents. Even confidential matters regarding inter-corporation contracts would apparently be thrown open to the public, were such a measure enacted as first introduced.

Fortunately there is not much likelihood of this particular legislation passing this year, but the trend of thinking which is evidenced by this bill deserves attention. It will bear watching because of the insidious nature of some of its ambiguous phraseology. Certain of its queer phrases appear to lay practically all patent contracts of a company wide open for inspection by even the most casual passerby.

There is possibly one proper purpose sought by such a measure. That is the supervision of patent cross-licensing which might by improper development create dangerous restraint of trade. It is under the guise of regulating that monopolistic trend, charged against certain patent pools, that this legislation gets its one justification. But that objective might much better be reached by other means.

If Congress will define the extent to which public interest attaches to such patent-pooling arrangements, then it would be proper enough to have filed confidentially with the Federal Trade Commission all contracts which lie within the legislative definition. This would not give improper publicity to anything which lacked public interest. Nor would it subject the individual patentee or individual corporation to the prying eyes of inquisitive competitors.

Such a plan would give to the federal government all needed opportunity for stepping in with investigations when there appeared to be a monopolistic trend. The Federal Trade Commission could be counted on to do all that is necessary to curb such trend, if ever it appeared in the patent cross-licensing contracts. More than this is neither justified, nor in the public interest.

Phosphoric Acid Forges Ahead in Three-Way Attack

WHILE more spectacular and more highly publicized developments have been under way in other branches of the fertilizer industry, phosphoric-acid technology has been going ahead quietly on three different fronts, bringing nearer to realization the dream of \$40 P_2O_5. Wet process, blast furnace, and electrothermal methods mark the directions of progress. Which is the best path to the desired goal? The Tennessee Valley Authority has, of course, selected the electrical process and is putting governmental resources behind its effort to develop a more efficient low-cost method that may lead to increased use of more concentrated forms of phosphatic fertilizers. Later in this issue appears the first of three reports on what has been accomplished to date at Muscle Shoals.

For many years sole reliance of the fertilizer industry for its agricultural phosphorus was placed on the superphosphate process. For other purposes phosphoric acid was obtained by the "weak-acid" process, treating phosphate rock with sulphuric acid and recovering the H_3PO_4 by settlement or filtration, purification and evaporation. Where phosphorus was desired it was obtained by reduction of the rock at elevated temperatures, using either fuel-fired or electric furnaces. But it was not until 1920-21 that success was attained in the effort to develop a continuous thermal process, yielding acid directly.

This process, the electric-furnace method of the Federal Phosphorus Co. (Swann Chemical Co.) at Anniston, Ala., was without a competitor in the production of strong, food-grade acid, until 1929. The fact had been recognized much earlier, however, that the reduction of phosphate rock with carbonaceous material, in the presence of a siliceous flux, was not dependent on the source of heat, but rather on the temperature attainable. As early as 1868 the blast furnace had been advocated as a suitable tool for this reduction. From 1917 to 1923 the U. S. Bureau of Chemistry and Soils experimented with the method, employing several types of oil-fired furnaces. Then in 1924 the first large-scale use of the blast furnace was attempted, culminating, in 1929, in the completion of a commercial-sized blast furnace by the Victor Chemical Works, at Nashville, Tenn. Having already spent over \$2,500,000 on development and on the first production furnace, the Victor company, in 1930, decided finally to abandon its weak-acid plant and to concentrate production in a new blast furnace of three times the capacity of the first.

By this time the casual observer would have concluded that the sulphuric-acid processes were doomed so far as further development was concerned and that for future advance he must look to the thermal methods. Such was not the case. Because it needed to dispose of its waste smelter fumes, Consolidated Mining & Smelting Co., of Canada, at Trail, B. C., was making contact sulphuric acid. And to utilize its acid, the company in 1930-31 installed a wet-process phosphoric-acid plant. The Dorr Co., Inc., was retained to design and construct the plant and this organization, in co-operation with a European affiliate, evolved a process which raised the strength of the acid produced from the 19-20 per cent P_2O_5 content of the weak-acid process, to 30-32 per cent, thus making notable economies in evaporating cost and yielding better extraction and better washing of the waste gypsum. The higher acid strength with the new process came from the use of rotary filters rather than thickeners for separating acid and gypsum; and from the discovery that by the recirculation of the reacting mixture from one of the later agitators (in which the strong H_2SO_4 was added), to the first, the gypsum crystal formation could be controlled for optimum filterability.

Since the Trail development, even the old weak-acid process has been materially improved, again by Dorr engineers. The recirculation process used at Trail has been found equally suitable for C.C.D. (counter-current decantation) plants where, in several cases, acid strengths have been increased from about 19 per cent to 21-22 per cent P_2O_5, with better extraction and washing and a better gypsum crystal formation. And, although it has not been developed commercially as yet, the Swedish Nordengren process, another strong-acid process employing a special type of band filter, is said to yield acid of 45 per cent P_2O_5.

How technology may improve and costs decrease in the future, and which of the three fundamental methods may eventually gain the ascendency, is not evident today. As has been mentioned above, the electrothermal process is the one that has been chosen by the T.V.A. for its initial experimentation. Another electric furnace plant has recently been completed in the New York region by American Agricultural Chemical Co., a plant which at first blush might seem to be handicapped by the fact that it is situated far from its raw material supplies and in a relatively high power-cost area. Yet cheap ocean freight for incoming rock, low outbound freight rates on finished product and a favorable power contract rumored to be in the neighborhood of 4 mills are economic factors not to be overlooked in any plant location. But neither of these two recent choices of the electric furnace method is necessarily indicative. The \$40 factory cost per ton of P_2O_5 in strong acid, that has been offered as the eventual criterion, is still in the future. Its attainment, an outstanding chemical engineering achievement, may as well be by one as by another of the three processes.

CHEMICAL ENGINEERING ACHIEVEMENTS & DEVELOPMENTS

Knowles coke oven plant at West Frankfort, Ill.

Processing Coal in Knowles Coke Oven

By R. S. McBRIDE
Editorial Representative, Chem. & Met.

Top of battery, showing coal larries, charging holes, gas offtake and fuel gas main

CONVERSION of low-value bituminous screenings to high-grade smokeless domestic fuel is the prime function of the Knowles coke oven as installed at West Frankfort, Ill., by Radiant Fuel Corp. Taking advantage of both low capital charges per ton of capacity and low operating expense, this installation accomplishes the economic beneficiation of almost waste fuel at costs that permit profitable operation. Clear evidence of the economic success is given in the fact that the first plant is shortly to be more than doubled in capacity.

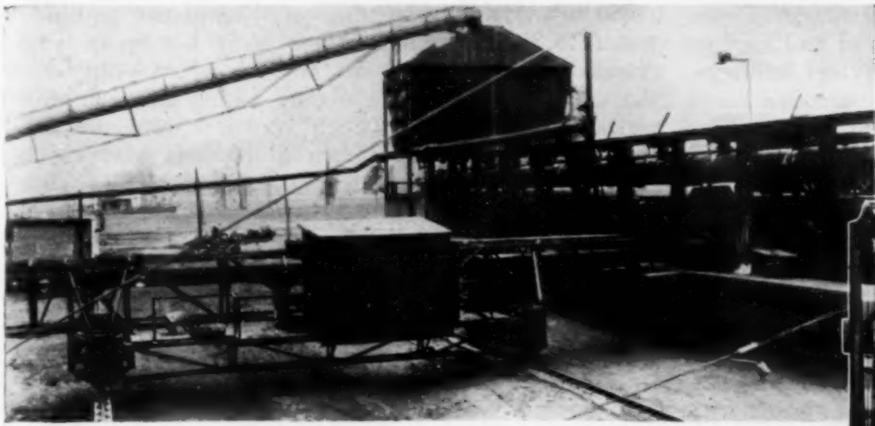
As operated at present, the plant consists of ten sole-flue ovens with accessories for coal handling, coke discharge and sizing, and gas-handling facilities with essential byproduct recovery apparatus. As enlarged, there will be 25 ovens of the same type, but no other important changes in the plant characteristics.

The coal used is fine screenings, the part of the mine production which passes through a $\frac{5}{16}$-in. screen at the Old Ben mines. The products are a domestic coke, called Carbonite, coke fines, tar, and surplus gas. Initially, no ammonia or light oil recovery is planned; but a sal ammoniac plant is in contemplation and, when economic conditions justify, light oil facilities may be added.

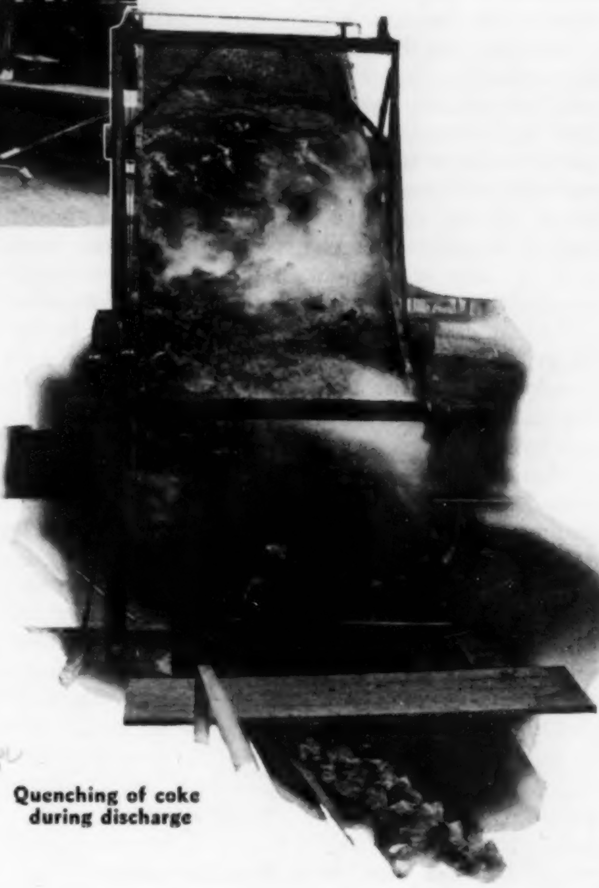
The fine coal as received is dumped into a railway-track hopper and carried to the coal storage bin over the ovens without any preparation or further crushing. The oven bin provides storage for 110 tons of coal and is equipped with four draw-off gates at the bottom for charging the larry cars.

The Knowles oven processes a layer of 10 to 12 in. of coal, spread on the silica-brick floor of the oven. The plastic zone formed first during coking travels upward through the coal mass during the entire period of carbonization. The products of destructive distillation and the moisture of the coal rise through the unsoftened coal and are thus not exposed to aftercracking as are the products in a typical vertical coke oven of the usual high-temperature type.

To some extent volatile tarry matter evolved from the plastic zone recondenses in the raw coal above. This, it is believed, tends to increase the coking power of fuels which otherwise would be feebly coking. The result is a high-strength, more rugged coke from mid-continent bituminous than is usually prepared in the standard high-temperature ovens. This, however, is gained without the disadvantages of graphitization which comes from secondary cracking of hydrocarbons while in the vapor state, a reaction inevitable with both vertical retorts and standard coke ovens. Greater yields of light oil and of the tar-acid constituents of the tar are also achieved by this method.



Pusher side of battery, showing door mechanism, coal-leveling and coke-discharging equipment



Quenching of coke during discharge

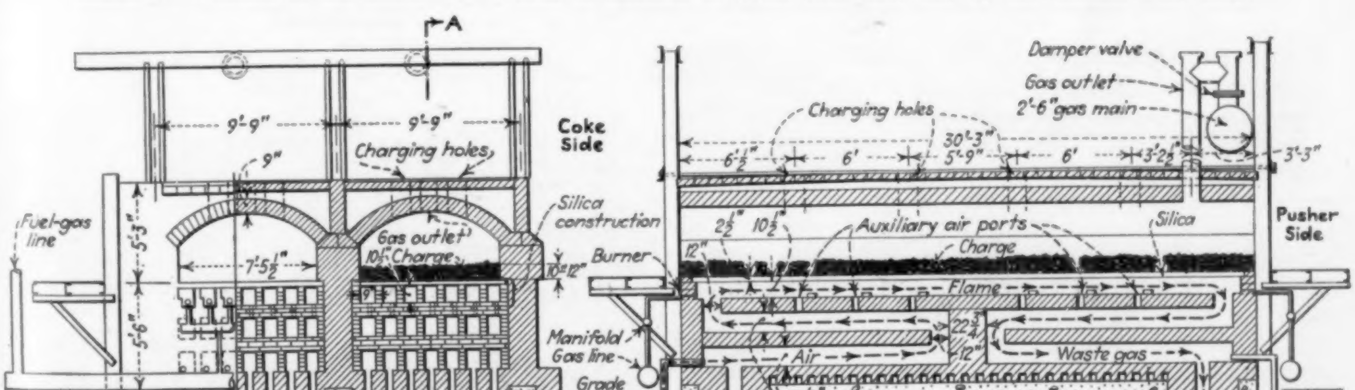
Heating is accomplished by burning some of the oven gas in the flues immediately under the oven floor. The heating system is duplicated on the two ends of the oven permitting reversals of gas, air, and exhaust-products, just as in the high-temperature oven.

The ovens are fired from alternate sides during successive 30-min. periods. The gas flame is stretched out as long as possible in order to give uniformity of heating along the length of the oven floor. This is accomplished by reducing primary air and feeding secondary air at several points along the sole flue. During reversals, the recuperator action of the refractory checkerwork of the flues functions just as in the more elaborate checkerwork of a high-temperature oven. Waste heat regenerators are provided for each flue, located directly underneath. The waste flue gases leaving these regenerators enter the stack at a temperature of 450 deg. F. to 500 deg. F.

The carbonizing temperature is approximately 2,500 deg. F., measured in the sole flue. The coke produced, therefore, has strength and ruggedness comparable with ordinary high-temperature coke. Because the secondary cracking of tar and oil vapors has not occurred in the midst of the coke after formation there is no graphitization of the surface of the coke. The Carbonite, there-

1370°C

Construction details of the Knowles coke oven as installed at West Frankfort, Ill., by the Radiant Fuel Corp.



Section A-A

fore, has combustion characteristics somewhat like low-temperature coke, notably ease of ignition and facility for supporting combustion at moderate fuel-bed temperatures. It appears that this distinctive combination of the advantages of high-temperature and low-temperature coke results primarily from the system of carbonizing the coal from underneath, instead of from both sides of the oven as is common.

The raw coal to charge an oven is introduced through eight charging holes in the top of the oven by four larry cars, each having two discharge hoppers. The eight cone-shaped piles on the oven floor are spread into a uniform layer by running the pusher arm, with pusher head removed, over the mass after charging but before closing the end doors of the oven. A charge consists of approximately 5 tons of raw coal spread 10 to 12 in. deep on the floor of the oven which is approximately 30 ft. long by 7½ ft. wide, inside dimensions.

Normal coking time for Illinois coal is 10 hr. per charge. Raw coal used here has approximately 10 per cent by weight of moisture as charged to the oven. The rate of progress of the plastic zone through the coal mass during carbonization is approximately 1 in. per hr., the same rate as the total coking speed found most desirable for the processing of this Mid-Western type of coal when heated from two sides in typical high-temperature ovens.

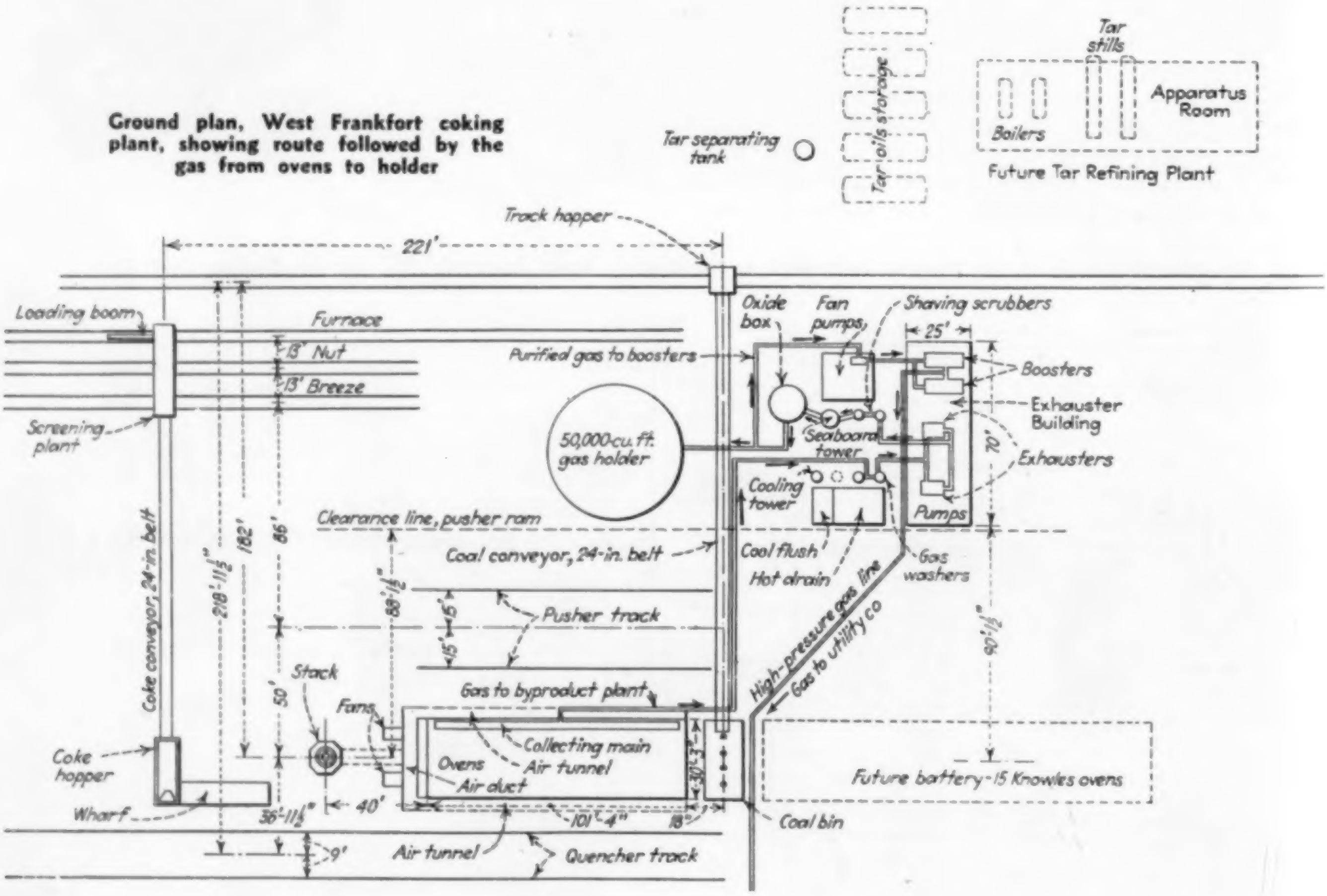
After complete carbonization of a charge the coke is pushed from the oven by a ram into a pan-like receiving device where it is quenched. The receiving pan contains about one inch of water when pushing commences and a spray mounted above the end of the receiving tray nearest the oven furnishes additional water to speed up quenching. Any hot spots which remain are hosed down at the coke wharf onto which the coke is emptied by merely tilting the quenching pan. From the wharf a chain conveyor draws the coke to a single roll crusher from which it is conveyed by belt to the coke screening and loading plant. Three sizes are prepared—furnace, pea, and breeze.

Gas and vapors driven off during carbonization are collected through an offtake into a crude-gas main on top of the battery, substantially as in the customary fashion for high-temperature ovens. The gas pressure inside the oven is maintained at about atmospheric pressure by the exhauster pulling through a mushroom-type damper, with butterfly valve control having precision of 0.02 in. of water pressure. The exhauster pulls the gas directly from the raw gas main and pushes it through shaving scrubbers for removal of tar, thence into sulphur-removal equipment.

A small Seaboard liquid-purification tower removes the bulk of the sulphur; it is followed by an oxide box for removal of the traces not economically removed in the liquid purification unit. The purified gas then enters the 50 M cu.ft. storage holder. Fuel gas for heating the battery is drawn from the lines after tar removal but before sulphur purification, since this heating gas can be used with full success even though carrying the normal raw-gas sulphur content. The surplus gas production is sold for public utility distribution in a group of nearby towns. It is pumped from this works at high pressure by gas-engine driven compressors.

Tar from the shaving scrubbers and traps flows to

Ground plan, West Frankfort coking plant, showing route followed by the gas from ovens to holder



an open concrete tank in which gravity separation from contained water is accomplished. The tar of 1.10 sp.g. readily settles to the bottom and the water overflows into a sump from which it is pumped for re-use in the cooling tower. This re-use of the water minimizes the water requirement of the plant and also prevents stream contamination by tar or oil should any escape from the water-separating mechanism.

The tar which normally runs about 2 per cent of free carbon and is very fluid at normal temperature is heated in the separating tank by submerged steam coils to reduce the entrained water. It is usually feasible to reduce the moisture content to 2 per cent or less before it is loaded into tank cars for shipment. No tar refining is practiced at this plant at present. The oven gas is typically of 500 B.t.u. per cu.ft. The tar, averaging 9 to 10 gal. per ton, contains 30 to 35 per cent of tar acids, more than double that typical of high-temperature tar.

An interesting special feature of the West Frankfort plant is the extensive use of small automobile engines for driving the various types of equipment. This sort of motive power was selected, of course, with modified carburetor equipment, in order to demonstrate the usefulness of the surplus gas for internal combustion engine use. Automobile engines are used on the pusher, quench car, as well as for stationary equipment with conveyors, pumps, exhausters, fans, and so forth. Of course, the engines on moving equipment, such as pusher and quench car, utilize benzol drip and gasoline, not gas. This, it is contended, well demonstrates the usefulness of low-cost, light-weight, internal-combustion engines as a source of plant power.

The operating force for the enlarged plant of 25 ovens will normally consist during each shift of a foreman and four men on the ovens and screens, one byproduct operator; and one mechanic. In addition there will be, on the day shift only, two men for unloading coal and miscellaneous work around the yard; one chief mechanic; one chemist; one clerk and storekeeper; and a superintendent. With this force the manufacturing cost is reasonably low, although it may be slightly higher per unit of coal handled than for large-capacity plants of standard byproduct ovens.

In general the equipment is intended for use in association with coal mines for the processing of surplus fines. On this basis low investment cost is a prime requisite, especially because small throughputs would be normal in such locations. The design has another distinct advantage for such installations in that the ovens, because of simple refractory construction, can be shut down and started up again with much greater flexibility than with typical high-temperature equipment. The builders believe that they have nearly the same flexibility as a steam boiler installation, because the brick work is similar to that involved in a boiler setting, except for the limited amount of silica construction in the sole flues and oven floor.

The capital investment required for the Knowles oven plant is considerably less than half of that necessary for a high-temperature installation of comparable capacity, it is estimated by H. A. Brassert & Co., engineers who control the patents for this process. The simplicity of oven refractory construction is one important factor in the low capital unit cost. An important economy is also achieved because of the relatively small unit quantities of coal and coke handled at a time which permits lighter construction of charging, pushing, and quenching equipment.

The operating expense for the Knowles oven plant is perhaps a trifle higher than for big ovens per unit of coal processed, because of the small unit quantities of fuel handled per charge. In the aggregate, however, the total of capital and operating expenses makes profitable the operation of small tonnage coking plants on screenings which would otherwise be marketed at a low price. Assuming these screenings are available at the coking plant at $1.00 per ton or less, the mine operator can convert them to a smokeless product having a value higher than even the domestic sizes of coal, and one for which there is a growing demand.

Blue Asbestos for Protection

BLUE ASBESTOS has been used in this country for many years but to a limited extent. It is said that this material is much more generally used in European countries. It contains 4 per cent water of crystallization and 40 per cent magnesia. The blue material is a sodium-iron silicate, while the white is a hydrated magnesium silicate. The differences in chemical composition result in differences in tensile strength, heat and acid resistance of the two materials.

Because of its high resistance to heat, plus its acid resistance, the blue asbestos makes a desirable heat insulation for use around acid plants and other places where acids are likely to come in contact with the insulating material.

In the production of hydrochloric acid, it is said to be customary in Europe to pack the towers with blue asbestos in the form of rope with a lightbraided jacket, or plain fiber. Chimneys handling the fumes of corrosive acids are likewise packed. It is important to remember that almost all acid and alkali plants handle their product with pumps, and that these pumps are almost uniformly packed with packing made from a blue asbestos base.

In the filtration of acids and alkalis it is said that blue asbestos cloth may be used. This cloth is little affected, is extremely strong, and can be woven so tightly that it is possible to dispense entirely with filter aids. In the production of hydrogen peroxide and chromic acid blue asbestos yarn is utilized to prevent the electrodes from making contact.

Blue asbestos is used in nitric acid plants as a cement, a putty and a packing. A soft putty for joints contains:

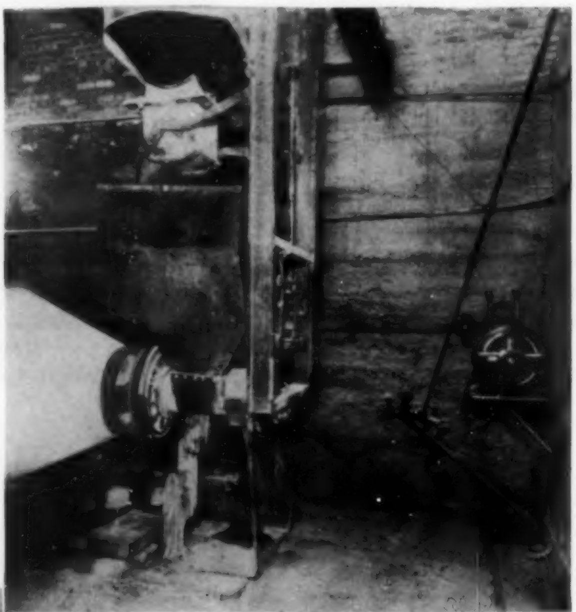
White asbestos powder	20 parts
Blue asbestos fiber	10 parts
China clay	10 parts
Linseed oil	20 parts

A cement for nitric acid plants contains:
Blue asbestos powder, and sodium silicate 1.5 Tw.

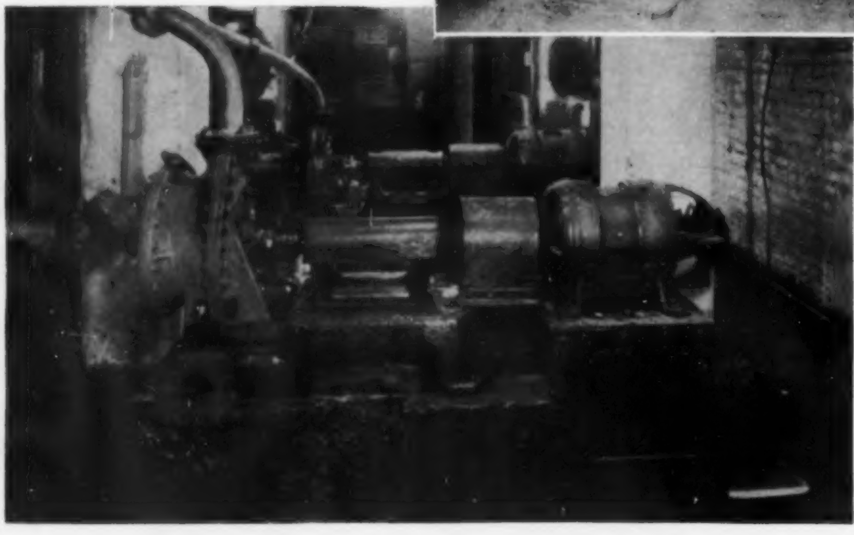
Motors
for
SEVERE SERVICE

Rarely are electric motors subjected to more severe service than under the dusty, corrosive conditions found in most chemical plants. The accompanying illustrations, showing a number of Westinghouse motors in operation at the Natrona Works of Pennsylvania Salt Manufacturing Co., demonstrate the sort of endurance required of chemical-plant electrical equipment.

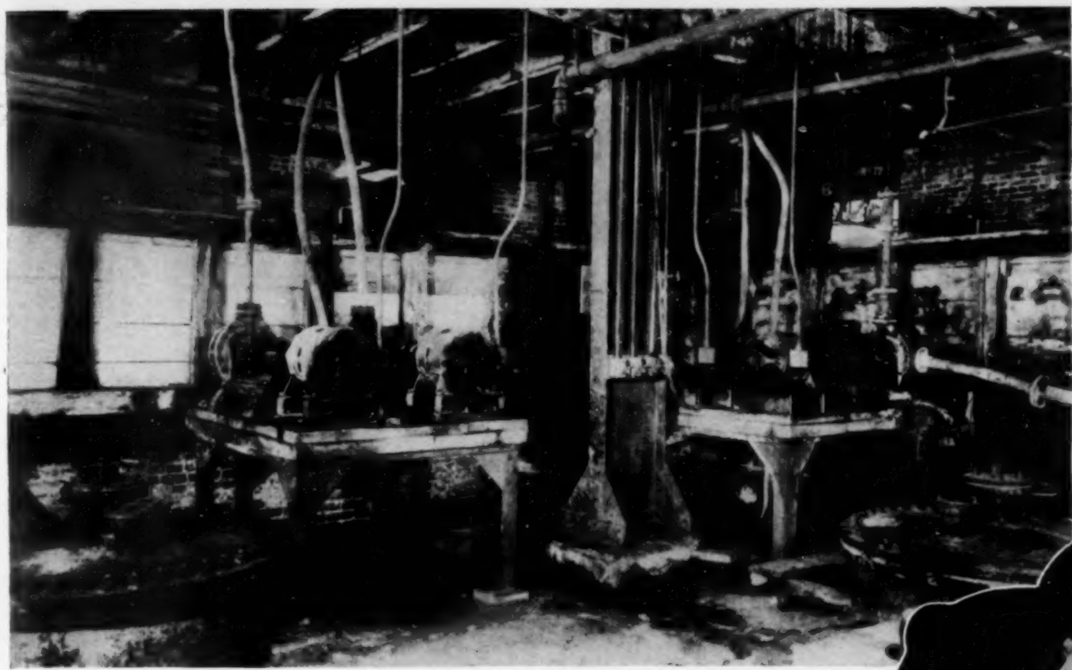
Except for one year when it was on different service in the same plant, this motor has driven a pump in the HCl department since 1908



Although coated inside and out with sulphur dust, this motor has driven a sulphur burner continuously since 1929 without damage to the insulation

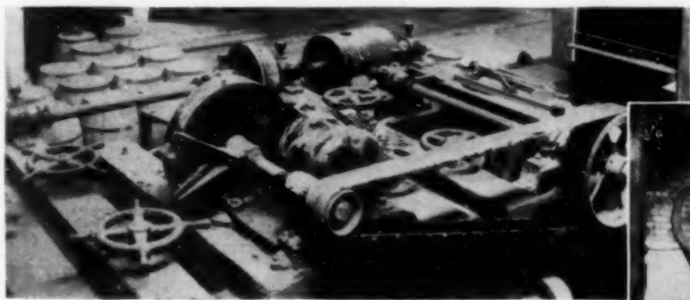


These motors drive sulphuric acid pumps; the one in the foreground has operated for seven years without insulation failure; the other shows no corrosion after a year's service



After five years' service driving pumps in the chamber sulphuric acid plant, this group of motors, equipped with sealed sleeve bearings, has not required rewinding or bearing replacement

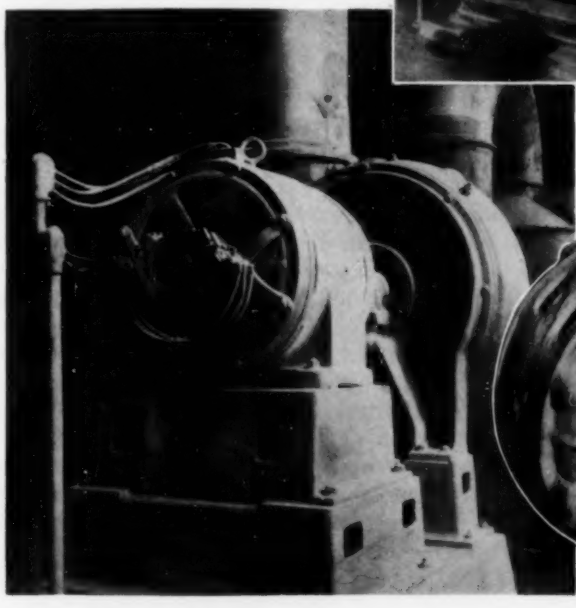
Below: This motor, in service since 1913 in the saltcake plant, has never required repair despite high humidity and much saltcake dust



Above: Since its installation in 1926, this motor driving a magnetic separator for kryolith has required no maintenance; this, despite the fine, abrasive character of the dust

Left: No maintenance since rewinding in 1927 is the record of this bauxite crusher motor which had previously served for 14 years in the caustic plant

With 14 years' service on a pyrites crusher, four in the power house and eight on a high-speed fan, this motor has needed repair only twice



Despite bauxite dust this conveyor motor installed in 1912 has had no maintenance record since a rewinding in 1914

What of the Future for Chemical Engineering Graduates?

By ANTHONY ANABLE
The Dorr Co., Inc.
New York, N. Y.

CHEMICAL ENGINEERING graduates of 1935, more than a thousand strong, are taking their leave from the college campus this month. During the coming weeks, with sheepskin in hand, with much theoretical knowledge, but with very little practical experience, they will knock for admission on the portals of industry. What does the future hold in store for this hopeful throng? What will be their rank in the salary scale, compared with that of their classmates trained in other branches of engineering? Do their best opportunities lie with the big chemical companies or with the smaller ones? And in a vast field such as the process industries, with last year's output valued at $6,595,000,000, what are the chemical engineer's chances, compared with those of other types of engineers, of attaining a position of executive leadership? Finally, in this technological world of ours, where all functional lines of business are feeling the effect of technically trained minds, what branch of industry, seemingly unrelated to chemical engineering, is offering new and gainful outlets for chemically-trained men?

To secure a clew to these questions, which today are uppermost in the minds of thousands of young men, one might go to the Massachusetts Institute of Technology, where the records of 134 chemical engineers, of a group of 161 graduates, are to be found in the files of Prof. Erwin H. Schell, head of the Department of Business and Engineering Administration. There, in tabular and graphical form, rest the statistics on men graduated over a period of 14 years—what they did at school, scholastically, socially, and administratively; what they subsequently accomplished in industry; and, rare indeed, the correlation between success at school and later success in business.

But before delving into these archives, let us examine briefly the men as a group, the scholastic fare of which they partook these four years, and the practical philosophy underlying the "administratively-trained engineer" concept of which Professor Schell has become the recognized exponent. For, after all, about 30 per cent business, economic, and cultural courses were mixed with 70 per cent technical, all of which introduces a departure from the norm of chemical engineering education.

Chemical engineering graduates out-distanced their classmates in mechanical, electrical, and civil engineering from the start

Behind it all lies an observation, made in 1913, that many engineering graduates do not follow their professions but become engaged in commercial and managerial pursuits. From this was conceived the idea of a new course, the aim of which was to furnish a broad foundation for ultimate administrative positions by combining with engineering training, instruction in business methods. Superimposed on a chemical engineering curriculum was an eight-point program in the fundamentals of administrative problems—economics, business methods, finance, law, marketing, production, accounting, labor relations.

From 1917 through 1930, 1,010 men were graduated in business and engineering administration. Of these, 711 majored in mechanical and electrical engineering, 138 in civil engineering, and 161 in chemical engineering.

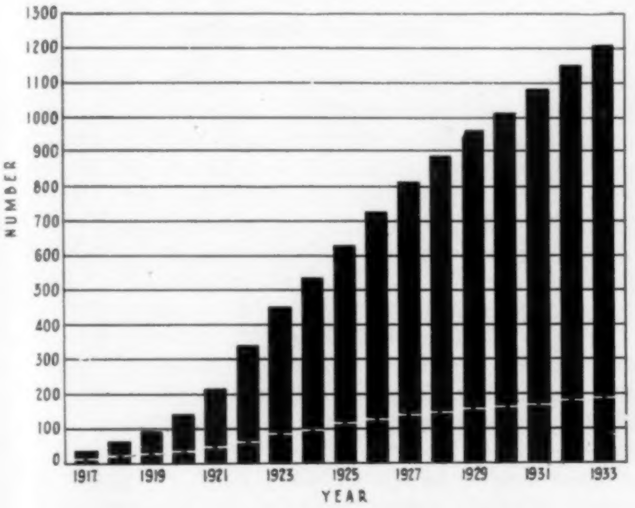
Complete records are available on 134 of these 161 chemical engineers. The diagram indicates the trend, the vertical, black column denoting the total graduates, accumulative, and the white line the number taking the chemical engineering option. As a group all of these men showed a responsibility trend into executive work as shown in a chart which appeared in an earlier article on this subject (See *Chem. & Met.*, Vol. 40, p. 84).

All indications point to chemical engineering being a comparatively lucrative branch of engineering. The chemical engineering graduates out-distanced their class-

mates in mechanical, electrical, and civil engineering practically from the start. All started out together at salaries averaging $1,500 a year and ran substantially neck and neck until the end of the second year, earning then about $2,000. From then on the chemical engineers pulled ahead, although, strangely, all groups drew together again on an even footing at the end of the twelfth year, at the $6,500 a year mark.

The thirteenth year shows the first effect of the depression. In this, as will be seen, the chemical engineers suffered much less than the other engineers. Apparently, after the first wave of salary slashing, industry took renewed courage and increased compensation liberally the next year. And a great year it must have been for the chemical engineers whose salaries skyrocketed to almost $10,000, fourteen years out of college, against $6,500 for the average graduate.

Let it be understood, however, that these last salary levels were those of the early part of a depression that many thought was merely a "psychological one" with "prosperity waiting just around the corner." A highly fitting sense of propriety has impelled the faculty not yet to query its graduates on their salaries since 1931.



Graduates of Business and Engineering Administration. White line indicates students taking chemical engineering. Totals are cumulative

Still, indications are that the chemical engineers fared better than the others just as their industry did in comparison with other heavy industries.

Chemical engineering pays well compared with the older branches. Probably this is because it is a relatively new industry, led by relatively young executives who realize the value of the educational advantages which have come since their undergraduate days. Furthermore, a bright young mechanic, an intelligent electrician, or an ambitious contractor may educate himself to hold down a position of mechanical, electrical, or civil engineer, but a chemical engineer must have technical education and seldom rises from the ranks without it.

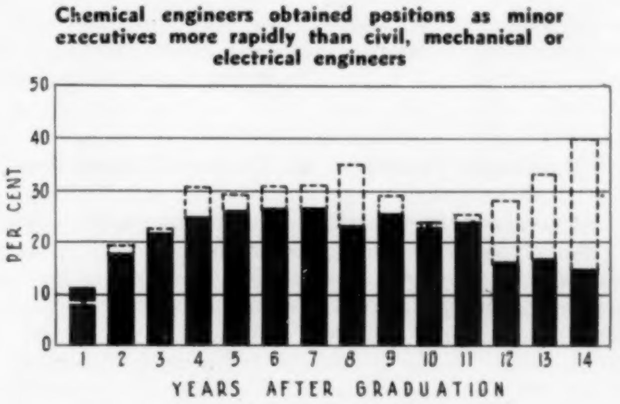
A big company or a small one, which should I enter? This question has always enlivened campus conversation during the weeks before graduation. Like a two-horned dilemma, the large company too often means financial security coupled with personal obscurity, while the small company means a bit of a gamble on future security, but a chance to demonstrate ability quickly and stand out boldly from a relatively small crowd.

Large chemical companies, not medium sized or small ones, claimed the greatest percentage of chemical engineering graduates. The trend to employment by large companies was much more pronounced in the case of the chemical engineering graduates than in the cases of their mechanical, electrical, and civil engineering classmates.

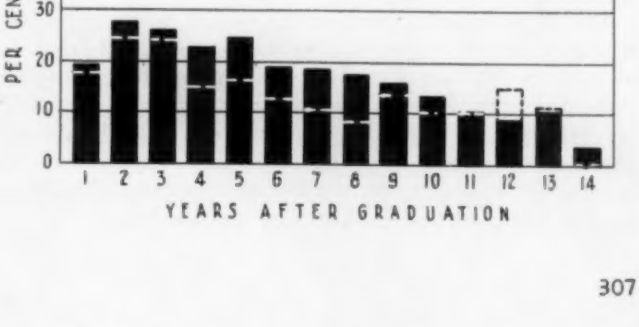
The terms "big," "medium" and "small" as used here require some explanation, for in this study size was not measured by the usual indices, such as capitalization, sales volume, or dividend disbursements. Classifications made on such bases as these did not break the companies down as desired, namely, according to types of management. As used in these studies the term "small company" means a proprietorship, a concern centering around one individual, who owns it and personally directs its every activity. A "medium-size company" denotes an organization, the operation of which is centralized in a few strong hands. The family spirit prevails and the stock is closely held. The "large company" is one in which operation is decentralized at a number of different plants.

Big companies not only attracted chemical engineering graduates more than other engineering graduates, but this lead was true year by year for fourteen consecutive years after graduation and became more pronounced as years went on. Chemical engineers, initially employed by medium-size and small companies, tended in later years to shift their allegiance to the larger organizations.

Chemical engineers obtained positions as minor executives more rapidly than civil, mechanical or electrical engineers



Chemical engineers engaged as technical supervisors, engineers, designers, research and development workers reached vanishing point in contradistinction to mechanical, electrical and civil engineers



To be sure, the fourteenth year after graduation does show a trend in the opposite direction, probably an abnormal one induced by uncertain economic conditions. Significantly, the 32 per cent of the chemical engineers who started with large companies grew to 40 per cent at the end of the fourteenth year, while the 20 per cent of other engineering graduates who started with large organizations shrunk to 14 per cent over the same period.

Chemical engineers tend to ally themselves with big concerns: mechanical, electrical, and civil engineers with smaller ones. This, on its face, would undoubtedly affect the relative rates of induction into positions of administrative responsibility. And this definitely proved to be the case upon scrutinizing the statistical data. Chemical engineers tended to advance more rapidly than their classmates in securing minor executive positions but were slower in becoming major executives.

In the fourteenth year, it would appear, that a full 70 per cent of all engineering graduates had attained the rank of major executives, while the same was true of only 20 per cent of the chemical engineers. On the other hand and in the case of minor executive positions, the chemical engineer after 14 years showed a 40 per cent coverage against 15 per cent for the entire group.

At first glance these comparative figures might be construed as evidence that chemical engineering graduates as a class possess executive qualities to a lesser degree than other graduates. This, however, is far from being the case. It has already been shown that the chemical group led all other groups in salaries earned and furthermore that they sought employment in large companies to a greater degree than the other groups. Consequently, it would appear that the answer lies in the fact that the minor executive in a large company has as much, if not more, administrative authority as the major executive in the small organization. Title held means nothing. Responsibility assumed is a far better index of executive ability.

Dominant Functions of Chemical Engineers

With salary ranges well crystallized and with a clearly evident trend into minor executive positions in large companies, one might seek the dominant functions being performed by the chemical engineers. In the early years after graduation, the largest classification into which all of the engineering graduates fell was a classification called "engineering specialists"—technical supervisors, engineers, designers, research and development workers, and so forth. But even in this group, where one would expect to find chemical engineers strongly represented, the chemical graduates year after year, with but one exception, lagged behind the others. By the fourteenth year, the per cent of chemical engineers engaged in purely specialized pursuits had practically reached the vanishing point in contra-distinction to the mechanical, electrical, and civil engineers.

But it was in the function of selling, including advertising, publicity, sales promotion, and the allied functions of modern merchandising, that the chemical engineering influence proved to be exceptionally strong. From the seventh year after graduation on, the chemical engineers placed proportionately more men in sales work than the other groups, ending up the fourteenth year with 20 per cent in sales, against 7.5 per cent for the others.

Marketing, after all, is said to have eclipsed production in recent years as the major problem of industry. Many hold it to be axiomatic that one can make almost anything one can sell. So selling has undergone a revolutionary change, particularly technical selling, and has drawn to its ranks an entirely different type of man. Thus, with an increasing demand for chemical engineers in selling it would appear that these men have acquired certain techniques in their formal educations that have given them a correct approach to the problem of merchandising.

Technical training does inculcate a "humility before the truth" as represented by the known facts of science. It conditions its men in a state of mind that instinctively reverts to known data, analyses and tests before drawing a conclusion or embarking on a course of action. In the past too much selling and advertising has been planned on guesswork and upon conjectures as to what the mental reactions of customers may be under certain supposed conditions. Therefore, may it not be true that the demand for chemical engineers in selling is due directly or indirectly to a refreshing new factual approach they bring to a function which has outgrown the hit-and-miss practices of the past?

Industrial Absorption

When we speak of the chemical industries today we are accustomed to think of a broader group, the process industries. In 16 of the process industries these graduates are represented as follows: Chemicals, 26; foods, 15; rubber, 12; textiles, 12; pulp and paper, 9; petroleum, 7; rayon, 4; soap, 3; pharmaceuticals, 2; leather, 2; gas, 2; explosives, 1; gelatin, glue, and adhesives, 1; lime and cement, 1; paints and varnishes, 1; sugar, 1; miscellaneous, 14; other work, 43; no data available, 5.

Of the 43 men engaged in other work, the largest number, 15, are in the investment business. Ceramics, coke, fertilizers, glass, oils and greases, and other process industries not mentioned are not represented.

Thus, the data compiled by Professor Schell and his associates serve as straws in the wind, giving perhaps a clue to what the future holds for this year's graduates in chemical engineering. The group studied was, to be sure, a small one, 161 men. But its value lay not so much in mere force of numbers, but in the completeness of each individual performance record, the care taken in their correlation and the spirit of confidence between instructor and student which is reflected by a more than 80 per cent return on all questionnaires.

But, after all, can one draw any definite conclusion from such data as these, involving only a little over a hundred men, all educated at a single institution of learning with their formal instruction in chemical engineering somewhat altered by an induced preoccupation on the commercial phases of industry as distinguished from the technical? Truthfully, the answer is no. Still, it may reasonably be expected that the hypothetical career of the hypothetical median man of this group, constructed from group averages may be of value as one element among the many from which a trend may be predicated. So let's have a look at the statistical set-up of this nebulous average special course chemical graduate.

At the age of about 22 he graduates with a training in all but the most advanced courses in chemical engi-

neering plus a well-balanced ration in business and economic subjects. If he has been an above-average student and has broadened his outlook by freely engaging in extra-curriculum activities, the chances are that he'll advance faster and go further than his less socially-inclined classmates. Time and effort expended on teams, publications, societies, committees, and campus politics, far from doing him harm will probably do him no end of good in adjusting himself happily to business situations.

The chances are 3 to 1 that he will go into one of the process industries, most likely chemical manufacture, foods, rubber, textiles, or pulp paper. If he happens to be one of the 1 out of 4 who forsake engineering entirely, he probably will go into investment banking, where his particular mental training will stand him in good stead.

No matter what he decides to do for a livelihood, he is an odds-on favorite to make more money than his classmates schooled in the older branches of the engineering profession. He has a definitely better stock in trade to merchandise to prospective employers and he probably will eventually get into the merchandising side of whatever industry he enters.

He may start out in a small, one-man proprietorship. He may begin with a medium-size company closely controlled by a small group of men. But, by the law of averages, he will probably settle down in a relatively large corporation with widely distributed ownership, where administration and production are geographically separated. His official title presumably will be that of a minor executive for many years. Still his responsibilities will be considerable and will equal or exceed those of many of his classmates who rapidly acquired high-sounding titles in small concerns where responsibilities on a purely quantitative basis are necessarily limited.

Fifteen years or so after graduation, our hypothetical median man may look back on college from the detached viewpoint of industry and ask himself what it was all about and what was the most valuable thing gained from a four years' battle with the books and beakers. A dozen men did just this last winter at a meeting with their former instructor. Chemical engineers and executives, bankers, merchandisers, no two engaged in the same branch of industry, but all with the same formal education, came to substantially the same conclusion. And that conclusion was that their education had given them a certain state of mind or industrial philosophy that outweighed any specific subject or course.

First and foremost among the elements composing this so-called industrial philosophy came "a humility before the truth"—in essence an engineer's abiding faith in cold facts, be they related to technology or to the practice of business. Next came "logical deduction," the scientist's habitual skillful wielding of these facts in reaching his conclusion. And finally followed "a sense of stewardship" which resolves itself into a feeling of moral awareness of the responsibilities and obligations of administrative leadership.

Appreciation is expressed to Professor Schell for access to the data presented in this article and the loan of the charts reproduced in it.

Purdue Surveys Its Graduates

THE PRINCIPAL FINDINGS of an exploratory survey of the occupational experience and earnings of the graduates of Purdue University from 1928 to 1934 inclusive have recently been completed. Primarily, this exploration was undertaken to ascertain certain facts by which graduates of the University might in part, at least, measure their chances for careers that included economic survival. As the items of information for individuals have been brought together, it becomes clear that similar studies by a number of institutions might furnish some guidance for the educational planning for the years immediately ahead, as President Edward C. Elliott states in the introduction to the report.

The data, collected and analyzed, involve a group of 2,140 graduates. Information was furnished by over 85 per cent of the members of this group. Of these recent graduates 9.9 per cent obtained their first employment prior to graduation; 63.4 per cent within three months after graduation. In other words, 73.3 per cent found employment before the end of three months after graduation.

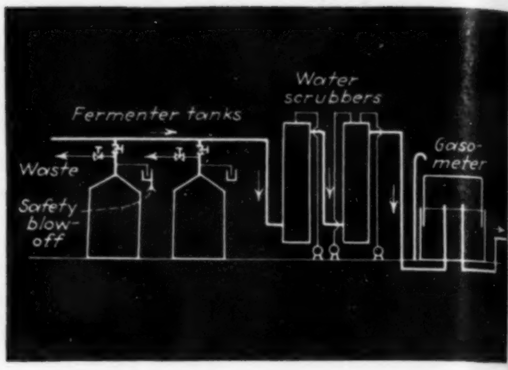
In the autumn of 1934 when the information was collected, 91.3 per cent of the entire group under consideration were employed—89 per cent gainfully, and 2.3 per cent represented by 100 housewives and 19 graduate students. More than two-thirds of those gainfully employed were engaged in activities for which they were specifically trained by the University.

So much for the group as a whole. Employment data and average salaries for chemical engineering graduates from Purdue are given in the accompanying table. It may be noticed that nearly every one of those graduating prior to 1932 were employed at the time of the survey. However, the members of the class completing their college work in 1932 did not fare so well, nine per cent were unemployed. While the graduates of the following year were all employed. Sixty-two per cent of the chemical engineering graduates for the six years were at work related to this branch of engineering.

Employment Data and Average Salaries of Chemical Engineering Graduates From Purdue University

	1928	1929	1930	1931	1932	1933	1934
No. of questionnaires sent	9	15	25	20	53	29	40
No. of questionnaires delivered	9	15	25	20	53	28	40
No. of answers received	8	16	19	18	46	25	38
Percentage employed	100	100	100	90	97	92	80
Percentage permanently employed	100	95	95	70	80	64	42
Percentage temporarily employed	.....	5	5	20	17	28	38
Percentage professionally employed	56	56	79	53	58	83	52
Percentage in work with little or no relationship to course taken in University	44	44	21	47	42	17	48
Average beginning annual salary	$1,710	$1,970	$1,755	$1,300	$1,135	$1,225	$1,138
Average annual salary in 1934	$2,125	$2,020	$1,838	$1,490	$1,325	$1,290	.....

Flow diagram showing Reich purification process and York low-pressure production cycle



Distiller Profits From Solid Carbon Dioxide

By W. N. NEIDIG
Mechanical Engineer
York Ice Machinery Corp., Brooklyn, N. Y.

AN INTERESTING EXAMPLE of a modern plant for the recovery of waste fermenter gas and the production of solid and liquid carbon dioxide has been furnished in the recently completed carbon dioxide plant of the New England Alcohol Co., of Everett, Mass. This company gave careful consideration to increasing its revenue by the utilization of all byproducts, a problem to which the distillation industry is paying much attention at the present time. In the design of this plant, special attention was given to the quality of the product, economies of production, ease of operation during continuous operation as well as during off-season low demand periods, and provision for future expansion.

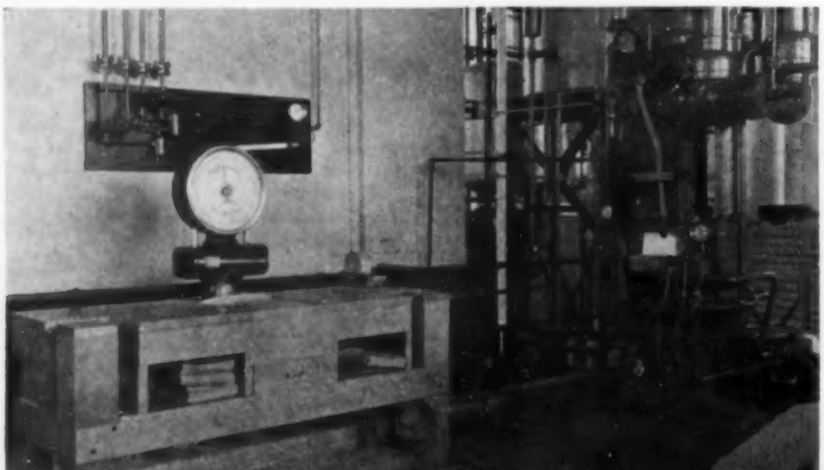
Equipment has been provided for collecting carbon dioxide gas from the fermenter tanks and for scrubbing and washing the gas; the Reich process is employed for deodorizing and purifying the fermenter gas, and the York low-pressure process in the production of solid carbon dioxide. A separate building, especially designed for manufacturing and handling solid and liquid carbon dioxide, is equipped with complete facilities for packing, storing, and shipping these products.

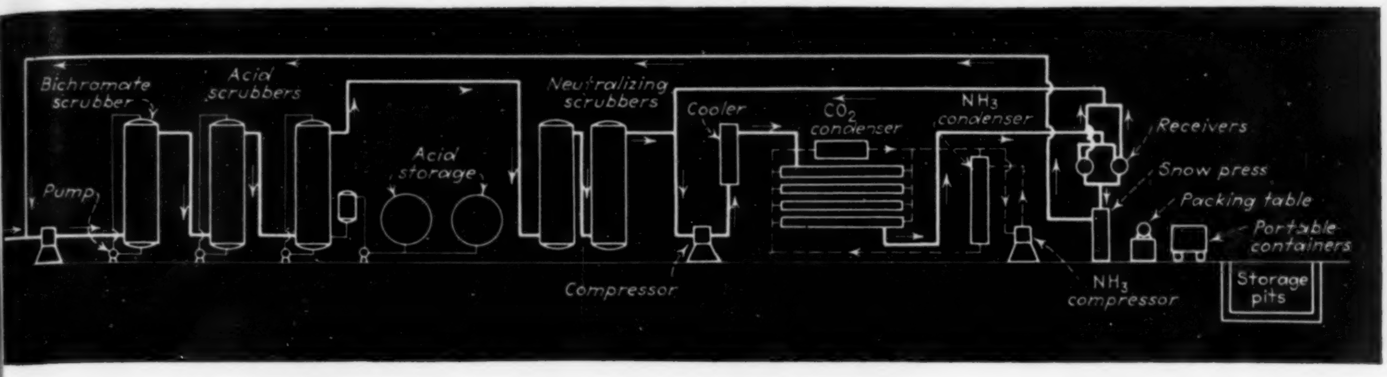
A most rigid and careful investigation of all processes and equipment used in the plant was first undertaken to insure a quality product at low cost and with a minimum capital investment. These investigations resulted in the selection of a single, carefully balanced production unit, operated by a high-efficiency, constant-speed synchronous motor with all accessory equipment designed to function at maximum efficiency at the rated capacity of the compression unit. Operation should always be at the rated capacity, as this is the condition offering maximum economy of power consumption, operating labor and so forth.

A total connected load of 199 hp. is required by the ten motors driving compressors, pumps, and the like; as some of these motors are for intermittent operation only, the average power consumption is considerably below this figure. The entire plant is handled by two men per shift, one machine room operator and one snow press operator; the latter wraps the solid carbon dioxide and packs it in portable shipping containers. Shipping and loading is done by the distillery shipping crew which devotes several hours each day to this work, while repairs and maintenance are taken care of by the regular employees of the distillery.

The equipment used in the production of solid carbon dioxide has an initial daily capacity of 20,000 lb.,

Dry ice is produced in blocks which are weighed individually on a dial scale on the wrapping table adjacent to the snow press





with handling equipment and gas purification machinery installed for increased capacity. Arrangements have been made for future expansion multiples of 20,000 lb. daily capacity.

The industrial alcohol plant, built by the Lummus Co. in 1934, is a modern plant for producing ethyl alcohol by fermentation of black strap molasses, at the rate of 8,000 gal. of 95 per cent alcohol per day (Collins, *Chem. & Met.*, vol. 41, p. 171, 1934). The fermenters are of the closed type, constructed of ingot iron with pipes arranged for carrying off the carbon dioxide gas formed during fermentation. Six fermenter tanks, operated on a complete cycle of 72 hr. for each, are arranged for progressive steps of charging, fermenting, emptying, and cleaning. Two fermenters are charged per day, with 12-hr. charging periods, wort and yeast being introduced simultaneously. Fermentation starts at once and has progressed an average of 6 hr. by the time the fermenters are filled; it is continued for an additional 44 hr., making a total fermentation of 50 hr. The emptying period is 12 hr., 4 hr. being allowed for cleaning.

Fermenter tanks are equipped with gas pressure controls, observation ports, and piping for leading the raw gas to the scrubbers of the purification plant. Controls are centralized, allowing the operator stationed on the control gallery to regulate conveniently the flow of gas from the fermenters to the gas purification process. All fermenter tanks are equipped with gas sampling lines leading to a central point on the control gallery, with sampling cocks arranged for convenient gas analysis. During the periods of starting or slowing down the operator can readily determine the quality of gas, and is within easy access to control valves for throwing on or cutting out the tanks feeding the dry ice plant. This operating schedule insures a constant flow of 99.8 per cent carbon dioxide gas to this plant. The fermenter tanks are operated under a slight static pressure sufficient to force the raw gas through the water scrubbers and into the nearby gasometer in the yard.

The production of merchantable solid carbon dioxide is principally determined by the operation of gas concentrating and purification process. A salable liquid carbon dioxide must be completely colorless, tasteless, and bone dry, without any trace of oil or other impurities. Applications of this product cover a wide range, from a food product to a completely dehydrated refrigeration gas (Jones, *Chem. & Met.*, vol. 40, p. 76, 1933). Since solid and liquid carbon dioxide are only different phases of the same product, the specifications for the solid variety are identical to those listed above for the liquid, with the additional requirement that the solid must be manufactured in dense, hard, "white" blocks, of granular structure, so that the product may be sawed in thin wafers and small pieces without any waste resulting from brittleness or irregularities in shape.

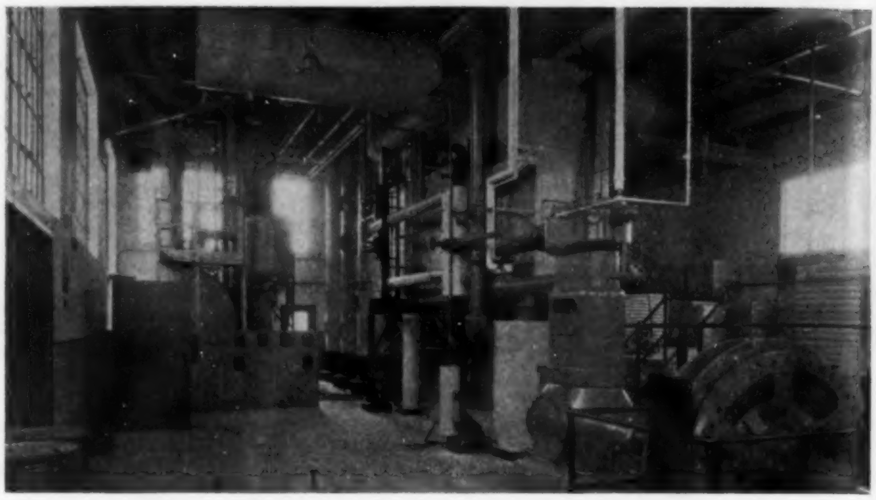
A purification process which continuously delivers gas with 99.8 per cent, by volume, of carbon dioxide, free from odors or impurities that will impart objectionable qualities to the product, and a process which delivers a gas having no objectionable action on the compression and manufacturing equipment, is required for making a high-quality solid or liquid carbon dioxide. The Reich process for deodorizing and purifying carbon dioxide gas was licensed to the New England Alcohol Co.; as operated in this and several other licensed plants it completely fulfills these rigid requirements. Cost of chemicals consumed in this purification process is less than 20c. per ton of solid material produced.

The first step in the process, which is carried out in the fermenter house, consists of three stages of water scrubbing, in two towers designed for the total capacity of the fermenter station. Each tower is equipped with a separate circulating pump so arranged that the water is moved progressively through the towers, in countercurrent with the flow of gas, to pick up entrained alcohol, otherwise carried off in the waste gas; the water discharges to the molasses dilution tank from which the alcohol is returned to the distillation process and recovered. The quantity of alcohol normally lost with the waste carbon dioxide gas from open-type fermenter tanks is estimated to be about 1 per cent of normal production, or about 80 gal. of 190 proof alcohol per day in a plant of this size. The operation of the water scrubbers is continuous and automatic.

The gasometer is the water-sealed type of gas container, and has a capacity of 4,000 cu.ft., which is about a 30-min. supply for the production plant. This instrument is of electric welded construction and is equipped with purging facilities, safety blow-off, and automatic water-heating attachment for winter operation. From the gasometer the washed gas is compressed to 75 lb. pressure and led to the second stage of the Reich purification process. The final deodorizing and purification operations are carried at this pressure.

The second stage of the purification process consists of a bichromate, two sulphuric acid, and two neutralizing scrubbers, designed for continuous operation and equipped with facilities for charging under pressure. A

2,500-gal. prime sulphuric acid storage with necessary appliances has been provided. A spent acid tank is also installed, with pumping facilities for moving the spent acid to the fermenter house, where it serves as an inverting agent for fermenter solution. This acid replaces acid originally purchased by the alcohol plant for this purpose. The acid is circulated through the scrubbers at a pressure of 75 lb. with two LaBour Elcomet pumps specially designed for this service. A third pump installed for charging prime acid to the towers and delivering spent acid to the fermenter house also serves as a spare pump for circulating sulphuric acid through either scrubbing tower. A La Bour pump designed for 75-lb. gage pressure is used for circulating the solution in the bichromate scrubbing tower. This scrubber is fitted with a solution make-up tank and feed bottle for charging under pressure during continuous operation.



Equipment arranged along two sides of a central aisle within convenient access of the operator

The five scrubbing towers in the second stage of the deodorizing and purification process, designed for the total capacity of the fermenter station, are of welded construction with dished heads and ring-type floor supports. All towers and vessels used in the purification process are constructed in accordance with the A.S.M.E. code for welded pressure vessels. The inside surfaces of these vessels, connections, and piping throughout the process are designed with special care to make them clean, smooth, and free from pockets which may provide points of infection or sources of tastes or odors. All connections are of the flanged type and all piping is of welded construction.

Purified, deodorized, bone dry gas, which is absolutely essential for the smooth operation of the production equipment, leaves the second stage of the purification system at about 75-lb. pressure and is compressed to about 430 lb. in the second stage compression cycle. At this pressure the pure gas is led to an ammonia cooled shell and York tube condenser where it is converted into a liquid. This liquid is cooled in liquid receivers located over the snow press; it is then led into the press, where it is subjected to a pressure of 2,000 lb. and formed into 10x10x10-in. solid blocks, weighing 90 to 95 lb. per cu.ft.

The compression equipment is a duplex unit consisting of York vertical single-acting, semi-enclosed compressors driven by a 175-hp. constant-speed, 2,300-volt synchronous motor. This compressor consists of two cylinders on the first stage for compressing the gas from atmospheric pressure to 75 lb., and a second stage cylinder for final compression to 430 lb. A separate cylinder on the compression unit handles ammonia gas for the ammonia cycle used for cooling the carbon-dioxide condenser and for dehumidifiers throughout the process. The compression unit is equipped with York partial bypass controls, with the necessary gas coolers between stages. The ammonia cycle includes a York vertical open-type shell and tube condenser, outside the dry ice plant, and designed for the use of river water (salt water). This ammonia cooling system is automatically controlled with a York high-pressure, float-controlled system.

The solid carbon dioxide plant is built on two levels, the machinery floor is about ground level, and the section of the building used for snow presses, storage bins, shipping, and so forth, is raised to convenient truck-level height for moving containers directly to trucks or railroad cars. The machinery section of the plant is designed so that all of the equipment may be conveniently observed and controlled by one operator. All equipment including purification scrubbers, pumps, compressors, condensers, dehumidifiers, controllers, and other miscellaneous equipment requiring observation and control are arranged along two sides of a central control aisle, within convenient access to the operator. Gas sampling and testing equipment is placed along this aisle and all temperature and pressure conditions throughout the process can be observed from it.

Purification scrubbers and circulating pumps are separated from the compression equipment by a 5-ft. concrete wall on which is mounted the miscellaneous electrical starting and control equipment. The entire plant can be started or stopped from one operating point located on this wall. Access, for observation and control of the bichromate mixing tank and feed tank, sulphuric acid storage tanks and miscellaneous appliances on the top and sides of the purification scrubbers, is provided by "cat walks," with easy access from the operating aisle.

Dry ice is produced in blocks which are weighed individually on a dial scale on the wrapping table adjacent to the snow press. From this table the blocks are stored in portable insulated shipping containers holding approximately one ton each. These containers are designed for convenient handling with lift trucks or overhead crane. A saw is provided for supplying the product in any size.

Recessed in the floor of the elevated section of the building are the five insulated storage bins, designed for holding the portable insulated containers. A specially designed electric crane lowers and raises these containers in and out of the pits and moves the heavy pit covers. These covers are so arranged that containers can be stored on top of the bins. This arrangement provides a

Shipping floor showing how the one-ton containers are handled. Storage pits on the right

storage capacity per square foot of floor area twice that obtainable by the method in common use. By this procedure the dry ice is not moved from the original insulated container until it is delivered to the consumer, thus eliminating shrinkage due to re-handling. The insulated shipping containers stored in insulated bins reduce storage shrinkage to a minimum during the seasons of low demand and intermittent plant operation.

A quick-reading dial scale is recessed in the shipping room floor for weighing the filled container before shipment. The shipping doors are roll type and are arranged so that a truck can back up to the door opening and the container moved onto it with a lift truck. A shipping platform is provided for moving shipping containers directly into railroad cars with lift trucks.

In order to provide maximum flexibility for merchantable products, facilities are installed for drawing the liquid carbon dioxide from the ammonia-cooled condenser to a receiver located above the bottle-filling dial scales, from which the liquid is filled directly into bottles. This equipment was installed as an incidental facility to the solid carbon dioxide manufacturing process, because a certain demand exists for the liquid product. There is, however, a growing tendency among bottlers of carbonated beverages and many other consumers of liquid carbon dioxide to install converting equipment and to purchase this product in the solid form, as a considerable saving is thus afforded. Another important advantage is the high-quality bone dry liquid thus obtained, as the solid carbon dioxide production cycle is of a nature which permits no trace of moisture to be carried into the final product. Presence of impurities, and slight odors are also difficult to detect in the liquid product, while in the solid form any defect can be easily observed.

A fireproof building, constructed of brick, steel, and concrete with a cement tile roof houses the plant. Large window space has been provided and the interior is painted white to provide a maximum amount of light. The plant was designed and built by the York Ice Machinery Corp. under the supervision of Josiah B. Rutter, chief engineer of the New England Alcohol Co. The latter company furnished the carbon dioxide gas from their fermenter tanks and the site for the solid carbon dioxide production building. The York organization supplied the building, purification and all production equipment and turned over the plant to the alcohol company.

Ford Uses Soya Bean in Plastics

IT HAS been known that soya bean derivatives enter to some extent into the manufacture of Ford cars and some of the processes involved were demonstrated at the Century of Progress Exposition. As the soya bean is known to be one source of furfural and as furfural can be combined with phenol to produce a moldable plastic, some have supposed that a resinous material of this kind might be involved. Efforts to secure the actual facts regarding the nature of the plastics of this kind being employed led to the following statement sanctioned by the Ford Motor Co.

"As a first step in producing molded products from the soya bean, the oil, occurring in the dried bean to the extent of about 23 per cent, is almost completely extracted by solvents. A continuous process of extraction has been developed which gives a residual meal containing less than one per cent oil. The extracted oil is used as an important ingredient in baking enamels employed as body finishes and as a core binder in the foundry.

"The dry extracted meal contains about 48 per cent protein, 6 to 8 per cent cellulose, and 38 per cent other carbohydrates. The production of molding plastics from this meal is based on the ability of protein to react with formaldehyde to produce a thermoplastic resin.

"Production of the finer types of resins involves separation of protein from soluble carbohydrates. Some phases of this separation have not been completely worked out, so that resins of this type have not yet been put to commercial use.

"Other types of resin have been produced by simultaneous condensation of the proteins and phenol or urea with formaldehyde in the presence of the cellulose and carbohydrates. Considerable quantities of resins of this type have been produced and used in molding buttons for horns, gear shift level balls, light switches and ignition distributor covers. These products show strength, moisture resistance and dielectric properties comparable to the phenol-formaldehyde resins they are displacing. Much larger quantities of these resins will be used in the future as manufacturing problems are worked out and equipment is installed."

Developing Better Technique in Experimental Chemical Engineering

EDITORIAL STAFF REPORT

BETTER technique in the application of the unit operations and processes of chemical engineering may well be expected of future graduates of our schools and colleges. That this problem of laboratory instruction is of importance to the profession was evidenced by the well-attended conference of teachers and industrialists held in Wilmington, Del., May 16 and 17, under the sponsorship of the American Institute of Chemical Engineers Committee on Chemical Engineering Education. More than 150 participated in the meeting and discussion of 17 papers in the symposium on Chemical Engineering Laboratory Design, Equipment and Use.

Dr. Harry A. Curtis, chief chemical engineer, Tennessee Valley Authority, who presided at A.I.Ch.E. Educational Conference

Dr. Harry A. Curtis, chairman of the committee, and vice-president of the Institute, opened the discussion with a brief statement of major objectives for a chemical engineering laboratory course. Such instruction, in his opinion offers the best means of developing

1. That measure of skill in engineering technique and manipulation which is desirable equipment for all chemical engineering graduates.
2. Ability to record experimental data, to interpret and present them clearly and accurately in report form.
3. Appreciation of the necessity for the type and methods of measurement required in chemical engineering processes.
4. Knowledge of process equipment and familiarity with its operation.

Prof. Harry McCormack of Armour Institute, whose well-known advocacy of adequate laboratory instruction was the subject of an unusual article in the February issue of *Chem. & Met.* added his view that this course offered by far the best means to formulate the young engineer's training in line with his future duties and responsibilities. What he learns by experiment is most likely to stick with him and prove useful in later life. Prof. W. R. Veazey of Case School of Applied Science visualized the chemical engineering laboratory as a place to lay bare the scientific fundamentals and to test out ideas and ideals. By leading to the practical through theory rather than the reverse, emphasis is placed on basic principles and not on transitory details. Prof. Arthur W. Hixson of Columbia also uses the laboratory to demonstrate and emphasize the importance of engineering variables and their control; his course finally leads up to plant design as the ultimate goal toward which the student strives.

With the broader objectives thus outlined by chemical engineering educators of long experience, the discussion turned to the more specific problems of design and equipment. Dr. Norman W. Krase of the University of Illinois set a high standard in his presentation of a plan for an ideal laboratory adequate for undergraduate instruction in the unit operations and processes. A building to cost approximately $90,000 and housing experimental equipment valued at $40,000 was suggested. His paper showed the details of the equipment selected, as well as the design of the building. It will shortly be published in *Chem. & Met.* Prof. C. A. Mann of Minnesota and Dr. J. C. Elgin of Princeton pinned their faith to more modest set-ups, yet both agreed with Krase in the view that the trend is toward variety and flexibility in providing laboratory experiments. Something more than mere testing of equipment performance is desirable.

To be a good workman, or a judge of good work, a man must know how to work with the common tools of the shop. J. H. Rushton of Drexel Institute and M. C. Molstad of Yale presented lists of shop facilities required for a chemical engineering laboratory. Pipe fitting and mechanical tools are needed: (1) to install (erect, adapt and connect) purchased equipment; (2) to maintain, repair and alter equipment; (3) to build new equipment for regular use and experimental work, and (4) to provide storage and handling equipment for chemical raw materials. An inventory of machinery and plumber's, mechanic's and carpenter's tools required for the Yale laboratory serving 25 undergraduate and 15 graduate students showed an investment of only about $750. Each year nearly $400 is spent on repairs and supplies of which chemicals cost approximately $150.

Since most of the courses are for undergraduates, emphasis must be placed on broad training in engineering technique rather than for more specialized study in research methods, according to Prof. Barnett F. Dodge of Yale. His philosophy of undergraduate instruction is that while you cannot teach a man to think, you can nevertheless guide and direct his thinking along helpful channels. Prof. Walter G. Whitman of Massachusetts Institute of Technology reported that his own views of

the value of laboratory work are changing and have changed as a result of ten years in industry. Pipe fitting seems less important than brain-building, and the stimulation of the powers of oral and written expression. It is more important that a man learn to use his head than his hands, according to Whitman's philosophy. He told of a "dishpan course" at M.I.T., so-called because of the relatively crude equipment used, but which nevertheless makes it possible to obtain essential data required for plant design. Some of these undergraduate reports and theses, as pointed out by Dr. Curtis, have been sufficiently original and comprehensive as to warrant publication.

Chemical engineering unit processes—as contrasted with the more commonly studied unit operations—came in for strong support from Profs. D. B. Keyes of Illinois and R. E. Montonna of Minnesota. The former's experience of a number of years in teaching a unit-process course dealing with oxidation, reduction, nitration, esterification, etc., has convinced him of the greater value of this approach to chemical engineering problems of equipment design and construction. It has further emphasized how very limited is our real knowledge of the essential factors required in designing chemical reaction equipment. Professor Keyes cited the esterification of ethyl alcohol with dilute acetic acid as an example of an industrial process that had to be worked out largely from an empirical basis. He made a plea for more articles and papers dealing with problems in the design of unit-process equipment.

Professor Montonna defines chemical engineering in terms of unit operations coordinated and in proper sequence to comprise a successful large scale process in which matter undergoes chemical change. But so far in developing our educational philosophy, he feels we have paid altogether too little attention to this "proper sequence and coordination" which can best be taught in connection with studies of the unit chemical processes. If care is taken in the selection and preparation of the experiments, it is possible to avoid most of the difficulties and objections commonly cited against the unit processes —viz., "sloppy" procedures, lack of engineering technique and absence of mathematical and quantitative data. He hails the recent appearance of Groggins' "Unit Processes in Organic Synthesis" as a useful text pointing the way to important trends in our educational philosophy.

What Industry Expects

Industry's viewpoint as the user of the product of the engineering school was helpfully presented by Dr. T. H. Chilton of the duPont company and D. E. Pierce of Charles Lennig & Co. Chilton stressed as an essential difference between the university and the industrial laboratory the fact that the latter's primary objective is the actual design of equipment for carrying out a successful commercial process. While filters, dryers, mills and evaporators can usually be bought on standard specifications, he pointed out that reaction equipment is nearly always of special design worked out in the development laboratory. The pilot plant, which is the next step beyond the chemical engineering laboratory in industry, is not and probably should not be a part of a university's equipment. In fact, as pointed out by Chairman Curtis, such an investment on the part of a school is likely to lead to specialized and narrow instruction.

David Pierce, ardent proponent of "The Halfway House in Industry" (see *Chem. & Met.* August, 1933, pp. 424-6) said that management asks just four questions of the chemical engineer in charge of development: (1) Will the process work? (2) What yield and raw material requirements may be expected? (3) What problems are likely to be met in design and installation of equipment? (4) What about costs and profits? The inexperienced man first entering the development laboratory may be surprised to find equipment lacking for many unit operations while for others he may have to employ crude makeshifts. He must adapt himself to wood and stoneware instead of more expensive alloys, to distillation with packed towers instead of more efficient bubble columns. Yet if a man is resourceful and utilizes his own ability as well as that of the experienced operators and research chemists with whom he works, there is a real opportunity and source of personal satisfaction in development work in industry.

Better Engineering Reports Needed

Report writing, which came in for incidental mention in nearly all of the discussions, received specific attention at the hands of Prof. A. W. Davison of Rensselaer and Dr. R. L. Copson of T.V.A. and formerly of Yale. The preparation of accurate, readable engineering reports is one of the requisites always stressed by prospective employers according to Professor Davison. Since important action involving expenditures of money is often based on such reports, they must present their facts so clearly and accurately as to avoid any possible misunderstanding. Discussion is important but conclusions must stand out. The outline used at R.P.I. for guidance of the student is as follows: (1) purpose of experiment, (2) presentation of theory and formulae, (3) description of apparatus and sketches or drawings, (4) outline of procedure, (5) group organization and performance, (6) calculations, (7) tabulation of results, (8) summary, (9) appendix and (10) bibliography. Professor Davison requires an average of two reports a week, each of which will take six or eight hours for preparation.

At the suggestion of the chairman, Dr. Copson outlined the type of laboratory report developed at Yale and since adopted by the chemical engineering department of T.V.A. Most industrial reports are of necessity a joint effort, prepared by the group leader with the cooperation of the others—all of whom sign it. Since these reports have to go to many people of different interests and serve a variety of purposes, it is desirable that they be complete. At the same time they must be readable and designed to give the busy executive a quick and accurate means of ascertaining progress and results on which further work may be directed. The outline differs from Professor Davison's in that conclusions and recommendations are brought forward for emphasis and convenience. It follows: (1) purpose of report and introduction, (2) review of previous work and the prior progress, (3) summary of present work, (4) conclusions and recommendations, (5) experimental data, (6) discussion of data, (7) experimental procedure, (8) calculations. Since patents are always in the background in industrial work, Dr. Curtis thought it well to emphasize the extreme care that should be exercised in preparing and preserving laboratory notebooks.

To Prof. W. L. Bueschlein of the University of Washington was assigned the broad topic "Correlation of Laboratory and Classroom Instruction." Students, he has found, are often confused by theories and data presented to them in lectures and these always mean more to them when related to experimental work actually accomplished. Laboratory work is specific. It gives the student more confidence in theories and at the same time stimulates his skepticism of erroneous deductions. All of which creates new interest and enthusiasm.

A statistical summary of replies to a questionnaire on chemical engineering laboratory instruction was ably presented by S. C. Ogburn, Jr., of Bucknell University, who is chairman of the Chemical Engineering Laboratory Committee of the Society for the Promotion of Engineering Education. His committee had queried 93 institutions and received replies from 86. Of this total about a fourth did not have any laboratory courses, although they awarded degrees in chemical engineering. Of the 52 institutions that have such courses, attention was directed to the unit operations in the following order of their frequency: Distillation (91 per cent of the schools); Filtration (89 per cent); Flow of Heat (85 per cent); Drying (82 per cent); Flow of Fluids (76 per cent); Evaporation (76 per cent); Size Reduction (64 per cent); Gas Absorption (58 per cent); Classification of Solids (50 per cent).

On the muchly debated question of whether or not the preparation of a laboratory manual consisting of general instructions for experimental work would be desirable, 73.1 per cent of the schools voted Yes and 25 per cent voted No. Several expressed approval with restrictions and reservations.

Subsequent discussion as to the feasibility of a manual indicated a very wide divergence of opinion once specific suggestions were analyzed. The better procedure, at least for the present, seemed to be an arrangement setting up a clearing house through which the different teachers could exchange copies of mimeographed outlines and experimental procedures used in their laboratory courses. Prof. Albert B. Newman of Cooper Union, who served as secretary of the conference, agreed to work with the Institute headquarters in a plan for this distribution.* Perhaps from such a pooling of resources and information, it would be possible within a few years to develop an acceptable manual.

The wholesome differences of opinion brought out by the two-day session led Prof. W. H. McAdams of M.I.T. to conclude that, after all, individuality of ideas has been and must continue to be the basis for progress in the chemical engineering profession. We cannot afford to standardize or accept uniformity in any important phase of our educational process if we are to remain flexible and continue to advance.

Plastics Solve Difficult Plant Problems

PLASTIC MATERIALS are being used in chemical works in increasing amounts as materials of construction. This is largely due to the fact that they are nonconductors of electricity, and therefore do not corrode like metals; they have resilience to absorb mechanical shocks; and finally they have a low specific gravity which makes them light to handle. The problem confronting the chemical engineer in choosing a plastic for making, or lining, equipment is difficult and to help him make a decision the available information has been collected together in a paper presented recently before the Chemical Society at London by M. B. Donald.

The condensed and hardened phenolic and cresylic resins are remarkably resistant to chemical attack. Thus, for instance, when using equipment made of this material in the preparation of aniline hydrochloride it is only necessary to fill the vessel with acid and pour in the aniline while stirring. It can also be used for making iron bromide, an intermediate stage in the preparation of alkali halides, from iron and the halogens. Although it is unsatisfactory for sodium hypochlorite it has been recommended for use with calcium hypochlorite and liquors containing chlorine.

Fans suitable for dealing with hydrochloric acid gas are available. They can be run at high speed with low power consumption and relatively low bearing loading. Formerly, for hydrochloric acid at relatively high pressures, it was necessary to use two or more fans in series. Even if the gas is at 100 deg. C., no trouble is experienced in starting up from the cold as in the case of earthenware. Fans and ducting of synthetic resin are suitable for dealing with air laden with chlorine or hydrogen sulphide as, for example, in rayon works.

Bubble caps of laminated resin have been used in a still for separating alcohol, furfural, cresol, and water. They were found to be satisfactory for the top and bottom plates where alcohol and water collect, but not for the center plates where they are exposed to mixtures of cresylic acids and furfural.

A centrifugal bell made of the synthetic resin is shown for the bottom discharge of large centrifuges, engaged for example in dealing with ammonium sulphate liquors containing free sulphuric acid in the mother liquor and working at temperatures almost at the boiling point. The lightness in weight compared with metal bells is a definite advantage from the point of view of labor of discharging. In 1915 steel centrifuge basket, used for treating a phosphoric acid residue containing sulphuric acid, was sandblasted, painted, and sprayed with resin. After drying it was baked for 18 hours and this process was repeated some 4 or 5 times. It was still giving good service some 11 years later.

The injection of live steam into a tank of cold liquid is always attended by a large amount of unnecessary noise and vibration. A specially designed silent nozzle for steam injection made of the resin, which is constructed in two adjustable parts, can be arranged so as to promote good stirring and mixing of the contents of the tank. Resin-coated impellers have been used for stirring a toothpaste mixture containing mildly acid corrosives.

* (EDITOR'S NOTE: Complete stenographic transcript for this meeting is now being edited by the Conference Secretary, Prof. Albert B. Newman of Cooper Union, New York City, with whom orders should be placed immediately for mimeographed copies.)

Computing Volumetric Components Of Fluid Mixtures

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FREQUENTLY, mixing operations with fluids involve retention of all original and added components within the container and for such operations computations of resulting concentrations are readily made. For many cases, however, particularly with gases, constant pressure and volume are maintained, which means that efflux* takes place equal in volume to the influx. The methods of computation applicable for no efflux have generally been used for this condition, however, without large errors in results where low or moderate concentrations of an added component, and no high dilution of an existing component, are involved. In the realization that the method so used involved error, rather elaborate corrections and approximations have occasionally been applied.

Additions of a Pure Fluid

The exact theoretical relation for the condition of free efflux, assuming perfect and instantaneous diffusion and no reaction within the mixture, can be stated as

$$V dx = V dy - x V dy$$

or

$$y = -\log_e(1-x) = +2.303 \log_{10}\left(\frac{1}{1-x}\right) \tag{1}$$

where V is the volume of the container, y the volume or quantity units of the added component, each unit being equal to V, and x the resulting concentration of the added component. Fig. 1 gives the concentrations, with free efflux, for additions of up to six volumes, and also the concentration curve for no efflux, based on the relation,

$$x = \frac{y}{1+y}, \text{ or } y = \frac{x}{1-x} \tag{1'}$$

It is seen that for concentrations up to 25 per cent, the difference in values for the two assumptions is not large, but for concentrations of 80 per cent, over twice the added component is required where there is no efflux as compared with what obtains for free efflux. If a higher concentration is desired, such as for the initial discharge from the receiver of a gas generator when it is connected with the line after starting up, 99 per cent concentration can be obtained by wasting a quantity equal to 4.6 times the volume of the receiver. If the computation is made on the basis of no efflux, 99 volumes would be indicated as needed to obtain the same result.

For increasing the concentration from an initial value of x_1 to x, the requirements with free efflux are given by the relation,

$$y = -\log_e\left(\frac{1-x}{1-x_1}\right) = +2.303 \log_{10}\left(\frac{1-x_1}{1-x}\right) \tag{2}$$

and for no efflux, $x = \dfrac{x_1 + y}{1+y}$, whence, $y = \dfrac{x - x_1}{1-x}$ (2′)

Additions of a Mixture of Fluids

For changing the concentration in the receiving container of a component that constitutes the fractional part, x_2, of the added fluid, the following relation governs the condition of free efflux:

$$y = -\log_e(x_2 - x) = +2.303 \log_{10}\left(\frac{1}{x_2 - x}\right) \tag{3}$$

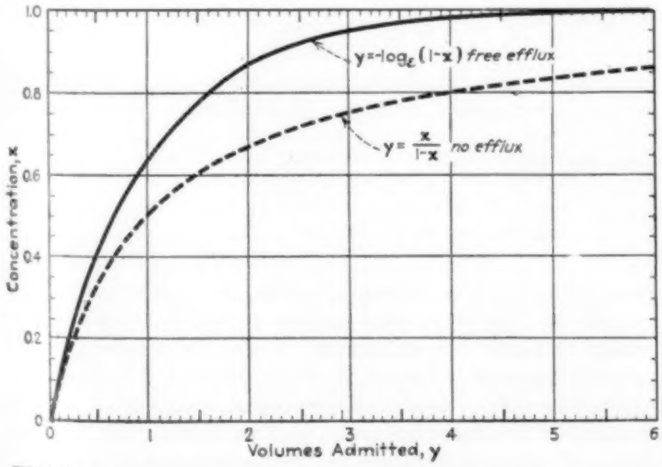
and for an initial concentration, x_1, of the given component in the mixture to which the addition is made,

$$y = -\log_e\left(\frac{x_2 - x}{x_2 - x_1}\right) = +2.303 \log_{10}\left(\frac{x_2 - x_1}{x_2 - x}\right) \tag{4}$$

which, solved for x, gives $x = x_2 - (x_2 - x_1)\, e^{-y}$ (4a)

For no efflux the relation with no initial concentration present of the added component is given by

Fig. 1—Relation of volumes of fluid admitted to its concentration



Publication approved by the Director of the National Bureau of Standards of the U. S. Department of Commerce.

Editor's Note—A fuller mathematical development for the cases treated in this paper, and also for intermediate conditions, was given in a paper by the author which appeared in *Physics*, 5, 64 (1934).

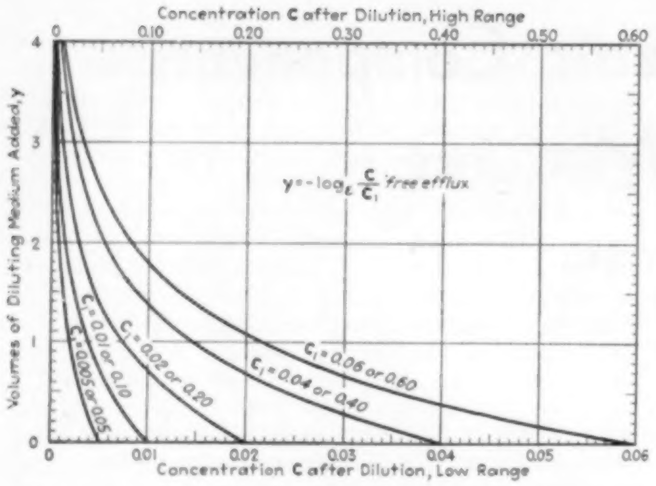


Fig. 2—Relation of volumes of diluting fluid admitted to concentration after dilution; free efflux

$$x = \frac{x_2 y}{1 + y} \quad \text{or } y = \frac{x}{x_2 - x} \tag{3'}$$

and for an initial concentration, x_1,

$$x = \frac{x_1 + x_2 y}{1 + y} \quad \text{or } y = \frac{x - x_1}{x_2 - x} \tag{4a')(4'}$$

Equations (4), (4a), (4'), and (4a') give general relations from which all cases of changes in concentration can be computed. Whether an increase or decrease in the concentration of a component is to occur will depend on the magnitude of its concentration, x_2, in the fluid being added, relative to its concentration, x or x_1, in the fluid to which the addition is made. As the addition continues, x will approach x_2 in value. If, at any stage, x_2 is greater than x, increase in concentration will occur; if smaller, dilution.

Common Case of Dilution

Where the component diluted is not present in the diluent the relation for free efflux is obtained by placing $x_2 = 0$ in equation (4), from which

$$y = -\log_e\left(\frac{C}{C_1}\right) = +2.303 \log_{10}\left(\frac{C_1}{C}\right) \tag{5}$$

where C_1 is the initial concentration and C_2 is the concentration after dilution. This can also be obtained by integrating the expression $dC = -Cdy$ between the limits, C and C_1.

In Fig. 2, which is a plot of equation (5) for given initial concentrations, two scales have been given which can be further extended if necessary, assigning successively scales lower by a divisor of 10 until the desired refinement in the result to be computed is attained. Thus, if a space given to hazardous processing or storage is flooded with inert gas containing 2 per cent of carbon monoxide in addition to the inert components, it is desirable to dilute this concentration to as low a value as 0.01 per cent to be assured of a non-toxic condition before the space is entered. Applying first the low scale in Fig. 2 and the curve for initial concentration of 0.02, it is found that 2.3 air changes are required to reduce the concentration to 0.002, and with successive reductions in the scale, 2.3 further for reduction to 0.0002 and an additional 0.7 for reduction to 0.0001, or a total of 5.3 air changes. If the computation had been made on the basis of no efflux, expressed by the relation,

$$C = \frac{C_1}{1 + y} \quad \text{or } y = \frac{C_1 - C}{C} \tag{5'}$$

199 air changes would have been indicated as required to obtain the same degree of dilution.

Dilution of Oxygen of the Air

Using the symbol, z, for oxygen concentration and taking the initial concentration of oxygen in air at the

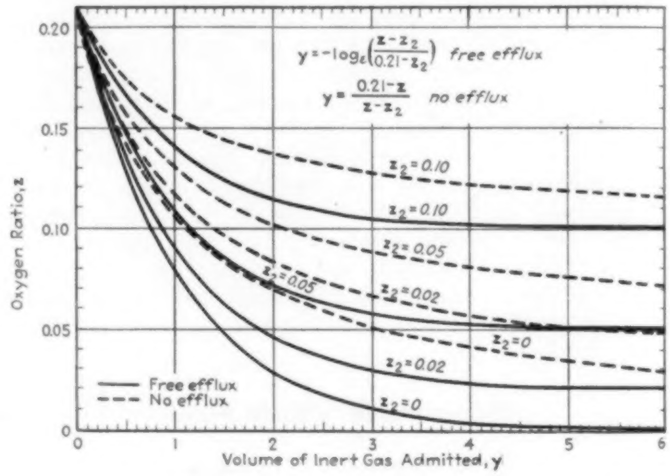


Fig. 3—Relation of volumes of inert gas admitted to resulting oxygen ratio

normal value of 0.21 and z_2 as the concentration of oxygen in the diluent applied (flue gas or engine exhaust gas occasionally used for the purpose may contain some oxygen), the following relation is obtained from equation (4):

$$y = -\log_e \frac{z - z_2}{0.21 - z_2} = +2.303 \log_{10} \frac{0.21 - z_2}{z - z_2} \tag{6}$$

This reduces to $y = 2.303 \log_{10} 0.21/z$ if no oxygen is present in the diluting medium.

In computing requirements for fire prevention and extinguishment with inert gas, the following relations applicable for no efflux have been generally used in American practice:

$$z = \frac{0.21 + yz_2}{x + 1} \quad \text{or } y = \frac{0.21 - z}{z - z_2} \tag{6'}$$

By comparing the values given in the solid and dotted curves of Fig. 3 an idea of the errors involved is obtained. Thus, for reduction of oxygen content to 15 per cent, generally regarded as required for extinguishing petroleum oil fires, fully inert gas equal to 0.35 of the volume of the inclosure must be admitted under the condition of free efflux, while on the assumption of no efflux, 0.40 volume is indicated. For reduction of the oxygen content to 8 per cent to extinguish fire and glow in ordinary solid combustibles, such as wood, the comparison

for the two respective assumptions is 0.96 to 1.62 volumes. That substantially free efflux must obtain is apparent, since increases in pressure during the admission appreciably exceeding 1 or 2 lb. per square inch would cause failure of masonry wall and floor constructions.

After flooding with inert gas, the oxygen content can be increased by ventilation, using normal air. Substituting $x_2 = 0.21$ in equation (4), the number of air changes required for increasing the oxygen concentration from z_1 to z is given by

$$y = -\log_e\left(\frac{0.21 - z}{0.21 - z_1}\right) = +2.303\log_{10}\left(\frac{0.21 - z_1}{0.21 - z}\right) \quad (7)$$

The ventilation requirements for several initial oxygen concentrations can be obtained from Fig. 4. To make a space safe for entry, an oxygen content of 18 or 19 per cent need not be exceeded provided any highly toxic constituent of the inert gas, such as carbon monoxide, has also been reduced to a safe concentration. Where carbon dioxide released from the liquid state is used, no extraneous components in objectionable amounts would be expected to be present.

In proportioning the requirements for fire extinguishment using a wholly inert gas, such as carbon dioxide, it is convenient to express the degree of protection given in terms of the number of cubic feet of room volume allowed per pound of gas provided as protection. This will vary with the type of combustible materials exposed to fire, the total room volume and, possibly, other factors, as well.

Carbon dioxide under 1 atm. pressure, at a temperature of 30 deg. C. (86 deg. F.), will weigh about 0.11 lb. per cubic foot, or 9 cu.ft. per pound. Assuming A cu.ft. of room space allowed per pound and y the resulting fractional number of volumes of gas that are admitted each equal to the room volume, then $A = 9/y$. Substituting for y in equations (1) and (1′), the equations and their evaluations for carbon dioxide concentration, as shown in the solid lines of Fig. 5, are obtained. By similar substitutions in equations (6) and (6′), with $z_2 = 0$, the resulting reduced oxygen concentrations are conveniently obtained as given in the dotted-line curves of Fig. 5.

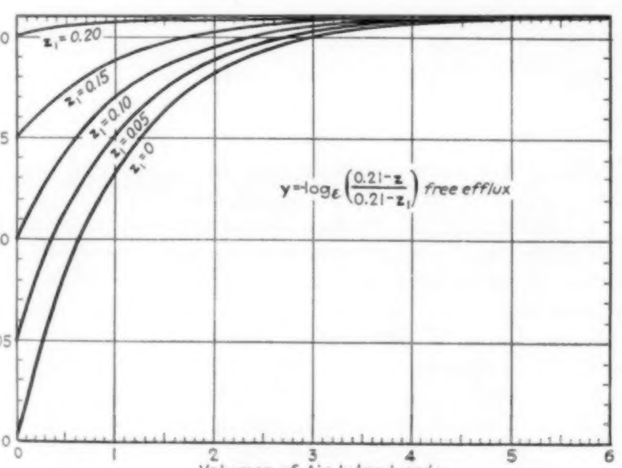


Fig. 4—Volume of air required to increase oxygen ratio to "z" from initial value, "z_1"; free efflux

Applications and Limitations

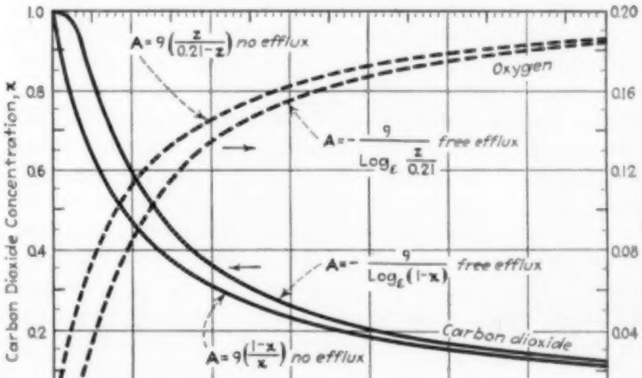
Some of the applications of the treatment have been given in preceding sections. Of other uses, the computation of toxic concentrations from leaking gas or refrigeration piping or equipment, or open gas jets, can be named. In such cases, if an estimate can also be made of the rate of infiltration of outside air, the limits of the possible resulting concentrations can be better established.

Mixture operations with liquids are generally made under the condition of no efflux. However, the condition for free efflux can be used to advantage if it is not feasible to control the amount initially present in the receiving container to give a desired concentration for given quantities of an added component. A desired concentration or dilution can thus be obtained with a smaller volume of added components. Suitable location of inlets and outlets, slow rate of addition, and thorough stirring, will assist in obtaining the desired precision for the concentration.

With the rate known at which an addition is made, a time function can be substituted for y in the respective equations. It should be noted, however, that the concentration at any time is equal to that computed as due to a single instantaneous addition of the quantity added up to the time concerned, irrespective of the rate of addition, assuming as in the present treatment that for the condition of free efflux diffusion is complete and instantaneous.

The latter condition is of course not actually fully realized in any case, but considering that generally the object of the operations concerned is to obtain a minimum concentration or dilution rather than an exact volumetric composition, mixture conditions can be arranged so that any errors resulting from the discrepancy will be on the right side. To achieve this, inlets and outlets should be located with respect to the relative densities of the components so that the efflux will be likely to contain less of the component being added than its average concentration at the given instant for the space as a whole. This condition is also promoted by the fact that the influx tends to impel a portion of the contents of the container ahead of it. It is, however, advisable to provide deflectors or other means of lateral dispersion near the inlets to prevent the occurrence of direct currents between them and the outlets.

Fig. 5—Oxygen ratio and carbon dioxide concentration resulting from admitting 1 lb. carbon dioxide to a given number of cubic feet of space



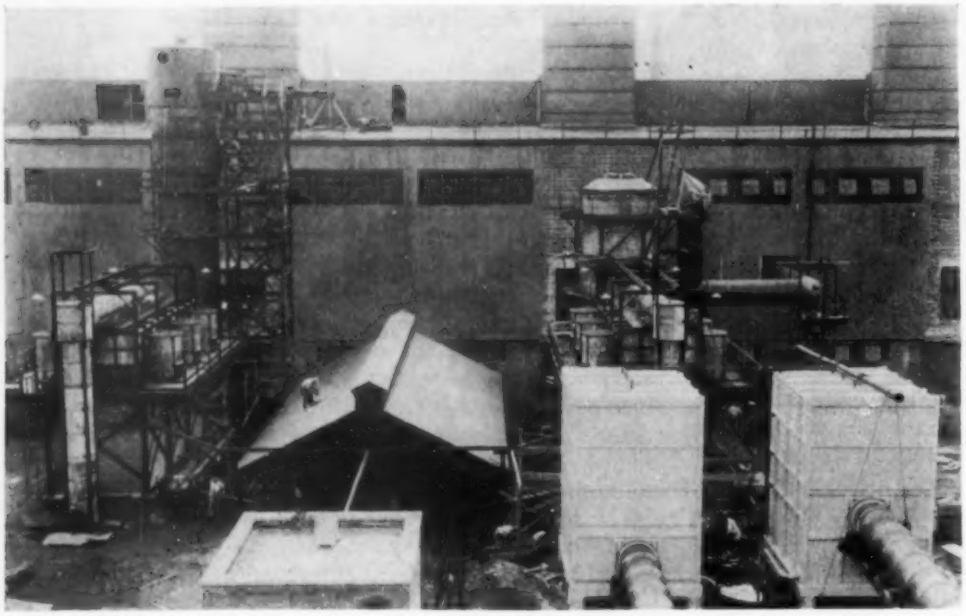


Fig. 1—View of hydrators, precipitators and waste gas scrubbers during construction of the T.V.A. phosphoric acid plant at Wilson Dam

T.V.A. Makes H_3PO_4 Electrically At Wilson Dam

By HARRY A. CURTIS

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This paper, dealing specifically with the phosphoric acid plant recently constructed at Wilson Dam, Ala., is the first of a series describing the results of investigations in fertilizer manufacture undertaken by the Tennessee Valley Authority.—*Editor.*

ONE of the great problems with which the Tennessee Valley Authority is wrestling is the prevention of soil erosion in the Tennessee Valley. The way to success in solving this problem lies primarily in an adjustment of agricultural practices in the Valley. This is an educational problem of such magnitude that only an agency with all the resources of a national government may hope to solve it. A readjustment of agriculture directed toward elimination of soil erosion calls for use of phosphatic fertilizers in new ways and on many areas not heretofore fertilized. To an important degree, the success of the program turns on developments in fertilizer technology and in methods of distribution which will deliver fertilizer to the farm at the lowest possible cost. The soil conservation program as a whole is a sincere attempt to apply government resources in the solution of a problem of national importance.

There are three methods now in commercial use for the production of phosphoric acid, namely:

1. Treatment of ground phosphate rock with diluted sulphuric acid; filtration to remove calcium sulphate and other insoluble materials; and concentration of the dilute phosphoric acid. It is difficult to concentrate the acid beyond about 50 per cent strength in the simple evaporators commonly used. There are several plants in the United States using this so-called "wet process."

2. Smelting of phosphate rock with coke and silica in a blast furnace; removal of dust from the gases produced; combustion of the phosphorus and carbon monoxide; hydration of phosphorus pentoxide to phosphoric acid; collection of the acid in a hydrator, followed by a Cottrell precipitator. This process yields concentrated phosphoric acid directly. There is one commercial plant using this process now in operation in the United States, namely, that of the Victor Chemical Co. at Nashville, Tenn.

3. Smelting of the phosphate rock with coke and silica in an electric furnace; combustion of the evolved gases; hydration of the phosphorus pentoxide; collection of the phosphoric acid in the hydrator and in a Cottrell precipitator. This process also yields concentrated acid directly. There are now three commercial plants in operation in the United States using this process, namely, the Swann Chemical Co.'s plant in operation for several years at

Presented by the author under the title of "The Manufacture of Phosphoric Acid by the Electric Furnace Method" before the Wilmington meeting of the American Institute of Chemical Engineers, May, 1935, and published in the June quarterly of *A.I.Ch.E. Transactions*.

Anniston, Ala.; the Tennessee Valley Authority's plant at Wilson Dam, Ala., which was put into operation in 1934, and a small plant in New Jersey built by one of the fertilizer companies and put into operation during the current year. White phosphorus has been produced for a number of years in small electric furnaces at Niagara Falls.

A considerable proportion of the phosphoric acid produced by the "wet process" has been used in the manufacture of fertilizers, the balance being used in production of purified phosphates of several sorts. Most of the phosphoric acid produced in the blast-furnace and electric-furnace plants has been purified to food-grade acid and used to manufacture such products as sodium phosphates and food-grade calcium phosphates, relatively a small fraction of the total having been used in production of fertilizers.

Nearly all the superphosphate of fertilizer grade now used in the United States is produced by treating ground phosphate rock with sulphuric acid. It contains 18 to 20 per cent phosphorus pentoxide equivalent. By using phosphoric acid in place of sulphuric acid, a superphosphate of 40 to 48 per cent phosphorus pentoxide content may be obtained. Obviously, if factory cost of the phosphorus pentoxide in the more concentrated superphosphate can be reduced to the cost of phosphorus pentoxide in the ordinary 18-20 per cent superphosphate, the more concentrated product can be delivered to the farm the cheaper, owing to saving in handling, in bags and in freight. This fact has been recognized for a long time, but, in general, it has not been possible to produce the concentrated product quite cheaply enough and it has been found exceedingly difficult to market the more concentrated product. The possibility of cheaper phosphate on the farm is today perhaps only one-quarter a problem of technology and three-quarters a problem of education of the consumer.

T.V.A. Fertilizer Works

Late in 1933 it was decided that one item in the T.V.A. fertilizer program would be to explore the possibility of economic production of phosphoric acid and a concentrated superphosphate through the design and construction of at least two electric furnaces, each of a different type, with the auxiliary plant required. Design of one of the furnaces (No. 1) was undertaken by R. C. Heaton, of the T.V.A. staff, and the second (No. 2) by W. E. Moore, of Pittsburgh. The Stone & Webster Engineering Corp. was engaged to design and construct one of the acid plants and all of the auxiliary plant. The Research Corp. was engaged to design and construct the other acid plant. The No. 2 furnace was put into operation in November, 1934, and the No. 1 furnace in January, 1935.

In Fig. 1 is a view of the hydrators, precipitators, fume washers and other equipment, during construction. Fig. 2 shows, in diagrammatic form, the general arrangement of the acid plant equipment. Fig. 3 is an isometric sketch of the plant as a whole, including the fertilizer section.

Phosphate rock is delivered to the plant by rail from the phosphate field of Middle Tennessee, and by barge to Wilson Dam from Perry County, Tenn. In the latter case the rock is unloaded from the barges to railroad cars and hauled thence to the fertilizer works near the dam.

A typical partial analysis of the brown phosphate rock from Middle Tennessee, of the so-called white phosphate rock from Perry County, of the coke and of the silica used is shown in the table on the following page.

The rock is crushed to minus 2-in. pieces and dried and the finer material (—$\frac{1}{8}$ in.) is screened out before the rock goes to the furnace. The screenings are ground and subsequently used in manufacturing superphosphate.

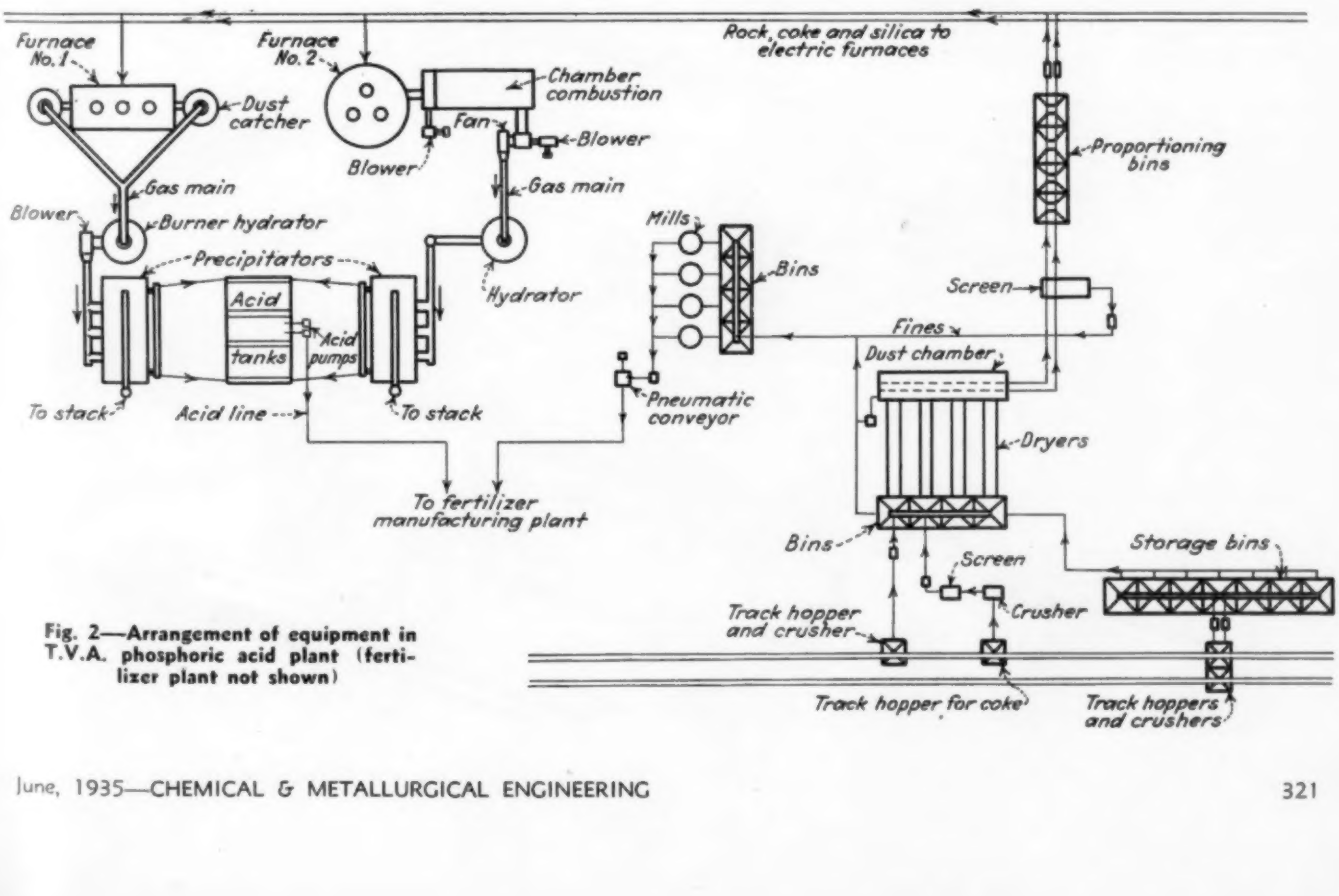


Fig. 2—Arrangement of equipment in T.V.A. phosphoric acid plant (fertilizer plant not shown)

Coke for the electric furnace charge is purchased in the Birmingham district. Screened coke breeze was used at first, but at present unscreened breeze is being used successfully. Silica is being obtained at present from gravel pits at Iuka, Miss. This is washed, the oversize crushed to —2 in. and dried and the —⅛ in. screened out. A typical furnace charge of the brown rock, coke and silica is shown in the table.

It will be observed that the fixed carbon in the coke is 10 per cent more than required to reduce the P_2O_5 and the Fe_2O_3 present in the charge. Small amounts of carbon are required for reduction of other oxides than P_2O_5 and Fe_2O_3 and there is a small loss of coke in the slag tapped. It is common practice to use a small excess over the theoretical for the phosphorus and iron.

The silica used may be varied considerably, but for reasons which will be given later in this paper, it is well to keep the CaO-to-SiO_2 mole ratio below 1.5.

Acid Plants

Electric furnace No. 1 is a rectangular furnace measuring roughly 9 ft. 8 in. by 19 ft. 3 in. inside dimensions below the roof arch, with a maximum depth of 8 ft. The bottom is lined with heavy carbon blocks and this lining extends up the sides to a point well above the slag pool. There are three electrodes, 30 in. diameter, suspended in a row on 5 ft. 9 in. centers. The electrodes are made up in 110-in. lengths, with inside screw threads in each end. As the electrodes are consumed in the furnace, new lengths are added by means of a short carbon screw male coupling and electrode clamps moved up.

The charge is fed into closed hoppers around each electrode, and the hoppers rotated to distribute the charge around the electrodes. Gas is withdrawn from each end of the furnace, passed through dust catchers and thence to a burner-hydrator. A balanced pressure, as nearly atmospheric as possible, is kept on the furnace at the roof. The gases leave the furnace at about 450 deg. F.

Slag is tapped continuously. This is much to be preferred to intermittent tapping. The slag is allowed to cool in cast-iron chill cars from which it is dumped into crushers and prepared for market. This furnace was designed to use 6,000 kw., and it was expected that there would be about 10 tons of phosphorus produced daily. The furnace was put into operation on January 3, but has not produced at full capacity for reasons which will be mentioned later.

Gas issuing from the electric furnace is essentially a mixture of carbon monoxide and phosphorus vapor in the volume ratio of ten to one, approximately. The heat of combustion of the gas is about equally divided between the carbon monoxide and the phosphorus and, likewise, about the same volume of air is required for the combustion of the two gases. The dew point of the phosphorus in the gas mixture is approximately 392 deg. F.

The general arrangement of equipment in acid plant

Composition of Raw Materials

	Brown Rock, Per Cent	White Rock, Per Cent	Silica, Per Cent
P_2O_5	33.1	31.3	
CaO	44.6	45.4	
SiO_2	5.0	10.2	95.0
Fe_2O_3	3.3	1.8	
Al_2O_3	3.4	1.8	
CO_2	1.1	2.6	
F	3.4	3.3	
Moisture	1.5	0.1	

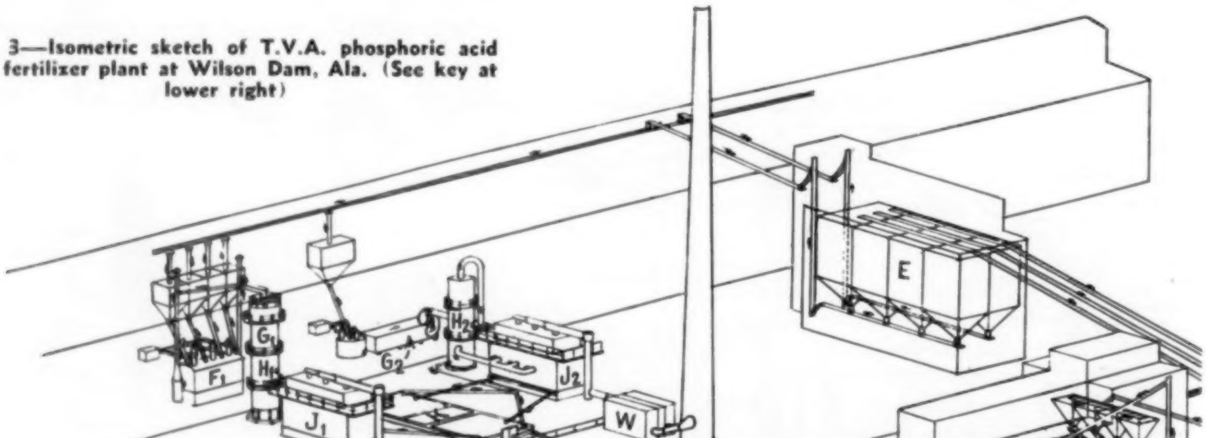
Coke, Per Cent

V.M., 1.9; F.C., 84.3; Ash, 13.8.

Charge, Lb.

Brown rock, 2,000; Silica, 718; Coke, 324.

Fig. 3—Isometric sketch of T.V.A. phosphoric acid and fertilizer plant at Wilson Dam, Ala. (See key at lower right)



No. 1 is shown in Fig. 4. The mixture of carbon monoxide is led to the top of a tower and burned with a large excess of air. In the lower part of the tower the gases are cooled by water sprays and the phosphorus pentoxide hydrated. At the foot of the tower additional air is added to cool the gases sufficiently to permit entry to the precipitator at about 300 deg. F. The exit gas from the precipitator is scrubbed with water and sent up a stack 200 ft. high.

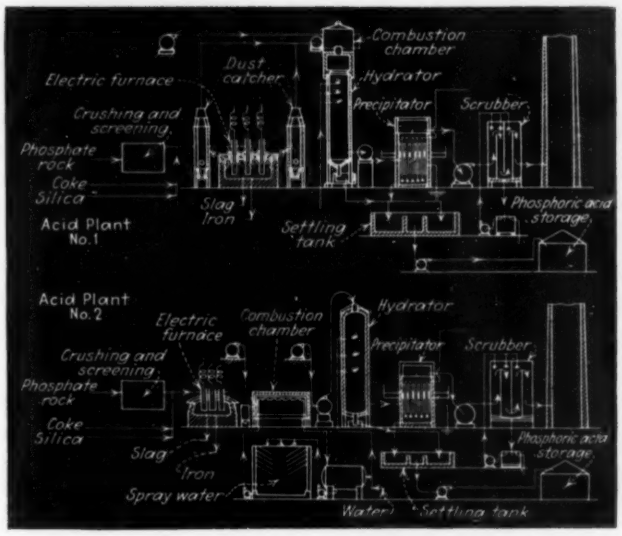
Electric furnace No. 2 is a cylindrical furnace 15 ft. 4 in. maximum inside diameter. Its maximum depth is approximately 8 ft. 3 in. The electrodes are spaced at the corners of a triangle. The charge was fed into the furnace at four points during the early months of operation, but later the charge was fed around the electrodes as in furnace No. 1.

No water cooling on the outside of the shell was used at first, but later the shell was water-cooled. The bottom of the furnace is carbon lined, the lining extending up the sides to a point well above the slag level. Slag is tapped continuously. The furnace was designed to draw 6,000 kw., but has not yet been operated at more than 5,500 kw. The power consumption per ton of P_2O_5 charged is about 4,800 kw.-hr. with the rather low grade rock used.

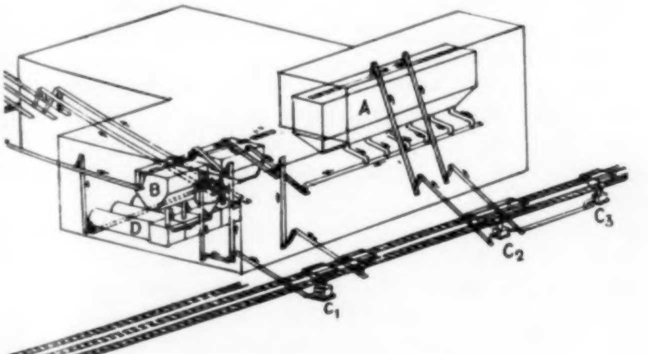
This furnace was put into operation on Nov. 7, 1934, and ran to Mar. 11, 1935, when a hot area developed on the bottom. It was then relined, and various minor changes made in the roof construction. It was put again into operation on April 2 and has been in production since then.

The general arrangement of this furnace and acid plant No. 2 is shown in Fig. 5. The carbon monoxide and phosphorus are burned with excess air in a horizontal combustion chamber 8 by 9 by 31 ft., located immediately adjacent to the furnace. Along the walls of this chamber are suspended metal tubes in which cold water is kept flowing. Approximately 50 per cent of the heat of combustion of the gases is absorbed in the water and dissipated in a water cooling tower. The gases are then further cooled to about 900 deg. F. by introduction of additional air. An alloy steel fan drives the gases to a spray tower where hydration is accomplished. The temperature of the gases is then further lowered by introduction of air to a temperature of about 300 deg., at which they pass to the precipitator. The exit gases from the precipitator are water-scrubbed as in acid plant No. 1 and then sent to the stack.

The acid from both plants is collected in acid tanks and pumped to the fertilizer manufacturing building.



Figs. 4 and 5, Above and Below—Flow sheets of T.V.A. phosphoric acid plants Nos. 1 and 2



Key to equipment shown

A, B: Raw material bins
C: Crushers
D: Dryers
E: Proportioning bins
F: Electric furnaces
G: Phosphorus combustion furnaces
H: Hydrators
J: Electrical precipitators
K: Phosphoric acid basins
L: Phosphoric acid tanks
M: Phosphate dust bins
N: Grinding mills
P: Mixers
Q: Ammoniation unit
R: Conveyor to storage
S: Fertilizer materials bins
T, U: Screening and bagging
V: Ammonia storage tanks
W: Scrubbers

Difficulties in Operation

Professional pride of the chemical engineer or policy of his company usually deters publication of difficulties encountered in starting new plants. When success has been attained and the grief of early operating days largely forgotten, there may be published a triumphant article citing all the achievements and concealing all the difficulties—with the result that the next adventurer along the trail finds no warning signs to save him from the pitfalls.

The present author is prepared to admit that the clear vision of hindsight has often made some of his errors appear ludicrous, and that both he and his employer have on occasion conspired to uphold the dignity of the profession. In the present instance, however, it appears that something of value to the progress of the art may be realized by a frank recital of some of the major technical difficulties encountered.

In the early days of operating furnace No. 2, for example, unfavorable conditions for the operators resulted from leaks of phosphorus vapor through the floor of the furnace. The steel side wall of the furnace should have been welded to the floor plate so as to give a gas-tight shell.

The tap-hole casting on furnace No. 2 was initially lined with refractory. The lining was soon cut out by the slag. A heavy carbon block with a small slag trough cut in it was then substituted and has given satisfactory service.

Furthermore, the carbon lining in furnace No. 2 was evidently not thick enough under the electrodes. It burned through in about four months of operation.

The problem of properly feeding the charge to a phos-

phorus smelting furnace has not yet been solved. In furnace No. 1, the charge was fed from chutes into closed hoppers around the electrodes, the hopper castings being rotated slowly to distribute the charge. The abrasion of the electrodes was too severe and the furnace was kept too full by this method. In furnace No. 2, the charge was fed into the furnace from several chutes led into the roof of the furnace. Preliminary small scale experiments had indicated that this would be satisfactory, but in practice it was found that the distribution of charge in the furnace was poor. Other schemes are now being tried on both furnaces.

Much trouble was experienced in the combustion chamber, fans and flues in acid plant No. 2. It will be noted from Fig. 5 that the gas issuing from furnace No. 2 is burned in a combustion chamber immediately adjacent to the furnace. The air introduced for combustion naturally carries moisture with it and this moisture hydrates the P_2O_5 to meta-phosphoric acid. This acid, mixed with dust carried over from the furnace, assumes all consistencies from that of heat-softened glass to that of molasses in January. The material (christened "gunk" by the operators) collects in the combustion chamber, on the fan impeller and in the flues and must be removed from time to time. Since it is too valuable to be wasted, it must be carried to the acid tank and dissolved, after which it hydrates rather rapidly (a few hours) to the ortho-phosphoric acid desired. Except to make provision

Fig. 6—Lime-silica equilibrium diagram

for handling the meta-acid conveniently, this operating difficulty will have to be accepted in acid plant No. 2, where it adds a little to the cost of the product.

In acid plant No. 1, it will be observed that the gas from furnace No. 1 is carried to the top of a tall tower, then burned downward into the tower, the lower part of the tower serving as a hydrator. This eliminates entirely the troublesome meta-acid problem. It is, however, difficult to get the gas to the top of the tower without allowing the temperature to fall below the dewpoint of the phosphorus (392 deg. F.). The combination of combustion chamber and hydrator in this particular design used does not permit satisfactory control of temperatures beyond the combustion zone. A modified design is now being developed.

It is, of course, obvious that the correct procedure is to condense the phosphorus from the gas stream and burn the phosphorus separately, thus saving the carbon monoxide as a fuel gas. This would reduce the heat liberated in the phosphorus combustion chamber to about one-half of the amount now produced, and would likewise reduce the volume of gas passing to the precipitator by more than 50 per cent. At the time the two acid plants were designed it was concluded that there was not sufficient information available on the condensing, handling and burning of phosphorus to permit using this scheme. In the light of a year's experimental work in these steps and several months of operation of the existing plants, designs for a commercial unit using the proposed system have been evolved and construction of the plant is in progress.

Corrosion Problems

Lead, as a material of construction in a phosphoric acid plant, is of little value. Under the most severe conditions encountered, it failed in less than 48 hours. Lead-lined steel pipes carrying cool concentrated acid (78 per cent) failed in a few weeks.

The resistance of the stainless steel known as KA2SMo is fair, but it will not stand up against weak acid where the temperature is above 300 deg. F. Preliminary laboratory results of corrosion tests on this metal proved misleading.

Duriron, although not recommended by the manufacturers for this service, has stood up very well so far. The lead piping which failed early in operation was replaced with Duriron, which is still in service after several months.

Carbon tubes, plates and other parts have shown no corrosion in contact with acid, nor has any serious corrosion appeared where acidproof masonry construction has been used.

Volatilization of Silica

The quantity of silica used in the furnace charge was initially adjusted so that, with the silica present in the phosphate rock, the mole ratio, $CaO/SiO_2 = 1.5$, would be obtained. This gave a satisfactory slag. Since the added silica is merely a fluxing agent it is obvious economy to use the minimum necessary. An attempt was made to reduce the silica in the charge to a mole ratio of $CaO/SiO_2 = 2$. This ratio gave a fluid slag, but the slag was very smoky as it came from the furnace, and it was found that much silica was being volatilized from the furnace, so much so that the acid flowing from the precipitator was milky.

Why the silica volatilized is evident from a consideration of the diagram reproduced as Fig. 6. As the mole ratio, CaO/SiO_2, is increased from 1.5 to 2 it will be observed that the melting point of the slag rises from about 1,690 deg. C. to about 2,140 deg. C. Now the melting point of silica is about 1,700 deg. C. and the vapor pressure of fused silica is high. The more basic the slag the higher its temperature of fusion, and the lumps of silica melting into this slag pool would vaporize considerably before reaction with the lime was complete. This view of the matter is hindsight; our original assumption was that the more basic the slag the more firmly the silica would be held.

Even with a mole ratio of $CaO/SiO_2 = 1.3$, where the melting point of the slag is about 1,470 deg. C., there is some volatilization of silica. At present a ratio of about 1.33 is being used.

Why Not Use Inductive Electric Heating?

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APPLICATION of inductive electrical heating at normal commercial frequencies to chemical process equipment has been so recent that there is no widespread knowledge of its advantages and disadvantages nor has any simple design technique developed in a form which can be readily applied by the average chemical engineer.

Fundamentally, the electrical induction heater is a transformer—a very poorly designed one from the electrical engineer's standpoint—but a very efficient one as far as the chemical engineer is concerned. A winding wrapped around the circumference of the chemical vessel is the primary; the vessel itself is the combined core and secondary. Practically every rule of good transformer design is violated, most of them intentionally; the result is the induction heater. The primary winding is made of low resistance and adequate insulated. This is almost the only concession to good electrical design. From this point deviation begins. An incomplete magnetic core is provided through necessity; this reduces the power factor and constitutes one of the serious objections to induction heating. The shell of the chemical vessel provides a heavy solid core which invites hysteresis and eddy currents—a plague to the electrical engineer but a joy to the induction heating designer. It also provides a one turn short circuited winding in which secondary current of great magnitude is induced. All energy passing into the hysteresis losses, eddy current losses, and the short circuited secondary appears as heat generated in the chemical vessel itself, precisely where the chemical engineer wants it. Whereupon he carefully confines it by efficient thermal insulation and secures temperatures generally not conveniently obtained by other methods.

Practical Applications

A number of practical installations are described in an accompanying table of pertinent data. All the installations operate on 60-cycle alternating current. It will be noted that the installations cover a wide range of conditions. Examples A to G give a series of more or less conventional chemical vessels. Example H is from a length of 2 in. extra heavy pipe. Example I is a gate valve on the same 2-in. line. The temperatures shown are not necessarily the operating temperatures, but the electrical data are consistent with temperatures shown.

The power inputs (kw.) given include winding losses of from 3 to 8 per cent, except for examples H and I, which run slightly higher. The overall thermal efficiencies, however, are higher than the indicated 92 to 97 per cent, since the winding loss reduces radiation from the vessel. The exact overall efficiencies would be difficult of determination, but probably lie in the range of 95 to 98 per cent. Gross heat input in B.t.u. per hour can be obtained by multiplying the kw. shown by 3,415.

The extreme flexibility of induction heating is apparent. The vessels were conventional chemical vessels, designed for particular process requirements, but with no modifications or special features to facilitate heating by induction. After the vessels were installed and lagged, ready for use, the electricians brought a coil of wire, a contactor or switch, and the result shortly was a suitably elevated temperature. Preceding the actual installation of the winding, of course, some engineering had been necessary. The scope and extent of which will now be considered.

Fields for Induction Heating

The essential mechanical design of the chemical reaction vessel, the maximum temperature desired, and the thermal cycle of the reaction are usually fixed before the type of heating is determined. Heat requirement is calculated by conventional methods which include proper allowance for heat into the vessel, heat into the reactants, heat into the reaction. and heat losses. Assuming that the temperature and amounts of heat, both total and per unit of time, are known, the method of heating is usually determined by either the temperature or the cost of the thermal energy. It is not within scope of this paper to discuss the economics of heating. Suffice it to say that electrical heating by induction is still electrical heating and the high cost per unit of heat must be justified by other advantages if induction heating is to be widely used. These advantages are usually the high temperature attainable, the ease of control afforded, or the inadvisability of jacketing or direct firing through some pecularity in the design of the chemical vessel or process.

Once a decision to use electrical heating is reached, a choice between induction heating and heating by the prefabricated resistance units must be made. There are on the market today a number of excellent heating units of the so-called space, pencil, strip, or immersion types. The relative costs of the two installations must be determined and the poor power factor and single phase requirement of induction heating given due consideration. It is, of course, possible to employ power factor correc-

Based on paper presented before American Institute of Chemical Engineers at Wilmington, Del., meeting, May 15, 1935.

Table I—Summary of Data on Induction Heating Installations

	Operating Data						Winding Data				Steel Core Data		
Symbol	Kw.	Amp.	Volts	Kva.	P. F.	Temp. °C.	Turns	Wire Size	Spacing, In.	Layers	Lb. Steel	Cross Section, Sq. In.	O. D., In.
A	25.2	190	216	41.1	.61	100	63	300 MCM	1	2	1,360	46	30
B	69.5	287	437	125	.55	455	38	250 MCM	1	2	11,000	155	66.5
C	160.	710	450	319	.50	480	25	500 MCM	1¾	2	29,500	305	98
D	22.9	211	210	44.2	.52	325	53	#0	Close	2	755	58	25.5
E	18.1	132	232	30.6	.59	20	75	#0	Close	2	2,500	235	20
F	42.0	257	216	55.4	.76	50	100	#00	1	1	2,880	103	14
G	4.17	31.7	216	6.85	.61	25	150	#6	Close	Multiple	350	60	11.5
H	.87	57	18.8	1.07	.81	600	80	#2	11/16	1	36	1.5	2.4
I	1.05	57	48	2.74	.38	485	70	#2	Close	Multiple	110	16	10

tive apparatus. However, such apparatus is relatively expensive and the equipment cost of induction heating when so saddled is usually greater than that of an equivalent capacity in fabricated resistance units. Why, then, is induction heating used for chemical process equipment? The answer lies in two words—temperature and transfer. Reliable heating units may be purchased for rated sheath temperatures of 1,200 deg. F. even higher. In practice, it is not always possible to work to these temperatures. The heat in a resistance element is generated uniformly and continuously throughout its length. Stop removing the heat in any portion and the temperature quickly rises, if prolonged, failure occurs. It is difficult, in the practical application of strip, space, or pencil heaters, to maintain perfect contact throughout their entire length. In low-temperature work this is not serious; with high temperatures, it is fatal. This difficulty is some times obviated by casting the units into suitable blocks of a metal or alloy and then clamping the blocks to the vessel or object to be heated. The more outstanding difficulty from lack of contact is eliminated, but a minor one of contact between the block and vessel is introduced. In any case, the cost is immediately increased to the point where induction heating is turned to in relief. Immersion heaters, while effective thermally and electrically, can rarely be used because of fire hazard, materials of construction problems, interference with agitators, and the like.

It sometimes becomes difficult to apply fabricated resistance units to the chemical vessel which has been designed for a particular function. An uneven contour may be presented, on which it is impossible to maintain contact between elements and vessel. Here again induction heating is indicated. There are additional problems where the sheer magnitude of the heating required precludes the use of anything but induction heating. An example of this is Item C of Table I which would have been a most difficult installation to have made with resistance units.

In brief, therefore, induction heating should be used: first, only where economically justified; second, where the operating temperature or difficulty of contact makes fabricated resistance units unsuited; and, third, where the difficulty of securing the desired input by other methods makes its selection mandatory. A supplementary, although not usually decisive, advantage of induction heating lies in its uniformity and absence of hot spots as may be supposed.

Method of Design

After having analyzed the heating problem and selected induction heating, the problem of designing the winding must be faced. This is the point where the difficulties appear insurmountable to the uninitiated. The rational method of design is to calculate the heating produced by hysteresis in the iron core, by eddy currents in the core, and by the heavy induced current in the shell. The method is rigorously correct, the mathematics are precise, the result is immediately to send the chemical engineer hunting for an alternative method of heating. Stripped of its complicated electrical terms and reduced to its barest physical essentials, the problem becomes less formidable. The variables which must be fixed by the designer are: (1) voltage, (2) size of wire, (3) arrangement of the turns both with respect to each other and to the vessel being heated, (4) number of turns, and (5) mechanical support of the winding. The frequency of the supply circuit is usually fixed at 60 cycles per sec. No data on performance at 25 cycles are available for inclusion here, although successful operation is secured at this frequency as well.

Table II—Effect of Turn Spacing

Winding		110 Volts			220 Volts		
Spacing	Turns	Kw.	Amp.	P. F.	Kw.	Amp.	P. F.
.84 in.	40	17.3	264	.60	83	701	.54
1.23 in.	40	24.3	346	.64	111	900	.56
1.40 in.	40	25.3	352	.65	129	1,000	.58
1.80 in.	40	29.2	410	.65	144	1,080	.60

Table III—Effect of Layers

Winding		110 Volts			220 Volts		
Arrangement	Turns	Kw.	Amp.	P. F.	Kw.	Amp.	P. F.
One layer	66	8.3	117	.64	40.5	315	.58
Two layers	66	4.7	73	.59	23.0	182	.57
Inner layer	33	22.5	332	.62	109	810	.61
Outer layer	33	20.0	385	.47	89.0	974	.42

Table IV—Effect of Turns and Voltage

	110 Volts			220 Volts			440 Volts		
Turns	Kw.	Amp.	P. F.	Kw.	Amp.	P. F.	Kw.	Amp.	P. F.
74	6.9	97	.65	33.7	249	.61	165	690	.54
68	7.8	111	.63	39.6	304	.59	190	815	.53
58	10.0	146	.62	51.1	391	.59	221	1,110	.45
48	13.7	200	.62	66.0	511	.59	.....	.....	.....
38	20.0	291	.62	95.0	755	.57	.....	.....	.....

Voltage

The voltage selected for the system is a matter of availability and convenience of construction. Obviously, the small installations are more conveniently operated at 110 volts, the medium at 220, and the large at 440. In this manner the number of turns required and the amperage remain reasonable for ordinary methods of construction.

Selection of the wire size is slightly more complicated. However, knowing the power input desired and having selected the voltage, the current can be easily calculated by making allowance for the probable power factor. Based on experience with widely varying shapes of vessels, the power factor will usually vary between 0.4 and

0.8, and it can be predicted with fair accuracy. A vessel which is long in comparison with the diameter and which contains a large mass of iron has a high power factor. A winding applied close to the vessel will have a higher power factor than one spaced further away. The winding should be applied directly to the shell if electrical insulation at high temperature would present a difficult problem. The variation in power factor is, of course, only a measure of the magnetic leakage. With a perfect linkage between the winding and the vessel, the power factor would be near unity, deviating from it only by the inherent inductance of the winding and of the shell. By reference to the various tables of this article the approximate power factor can be predicted and the amperage calculated. Here it is well to point out that the wire size selected should not be too small, as simple calculation will show that at the higher amperages an appreciable loss can occur in the winding. A good rule in selecting wires is to follow the regulations of the National Board of Fire Underwriters for interior wiring for "Other Insulations."

Arrangement of Turns

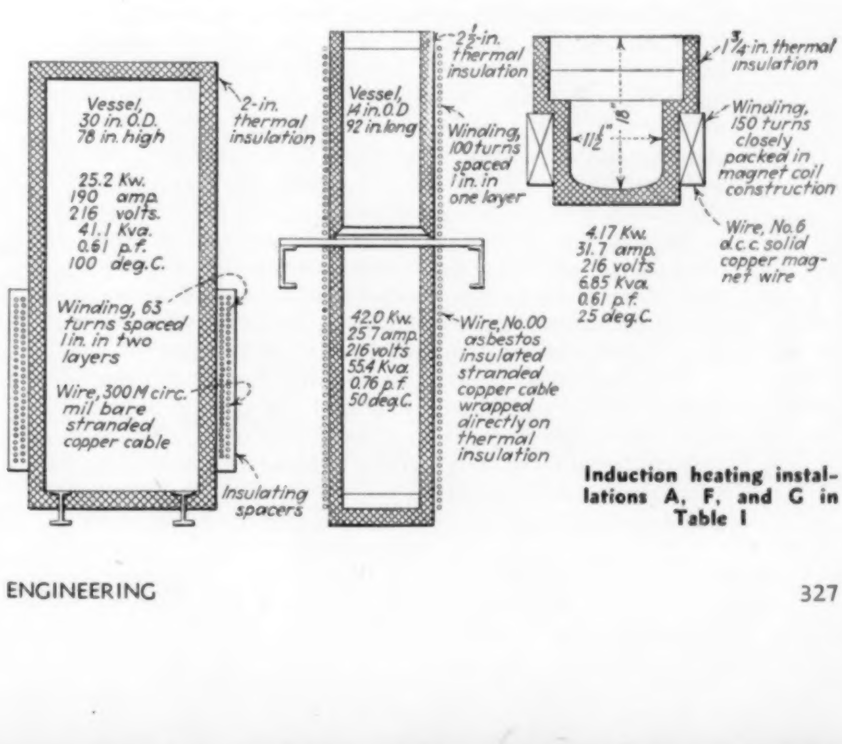
After selecting the size of wire, the next factor is the arrangement of the turns. In general, it can be stated that the winding should be applied as near to the chemical vessel as adequate thermal insulation will permit, it should be wound in one layer if possible, and it should cover as completely as feasible the entire surface to be heated. While heat will be generated in any portions of the steel exposed to a varying magnetic flux, it will be appreciably more effective in the immediate vicinity of the winding. The effect of changing some of these variables is shown in accompanying tables. In Table II it will be noted that by increasing the center to center dimension of the spacing of turns of No. 4/0 wire from 0.84 to 1.80 in., an increase in input of about 71 per cent was secured with the same number of turns. The power factor was slightly improved. Increasing the spacing of the turns would, therefore, distribute the heat over a larger volume and increase the number of turns required for a given power and voltage, compared to the number required for the same power and voltage if the turns were closely spaced. The former is the determining factor, while the latter is of importance only in that the necessary allowance must be made in estimating the number of turns.

The data shown in Tables II, III, and IV were secured by experiment on the vessel of installation A, Table I. Due to the wide variation in the load conditions, the actual applied voltage could not be held to a constant value and the readings were corrected to the nominal voltages of 110, 220, and 440 to facilitate comparison and correlation. The winding was constructed of No. 4/0 stranded weatherproof wire wrapped directly on 2 in. of thermal insulation. The temperature of the steel was maintained at approximately room temperature by circulating water through the vessel. The power loss in the winding was calculated and deducted from the indicated input.

In Table III, the effect of arranging the turns in a double layer is shown; the power factor was noticeably less for the outer layer than for the inner. In addition the input for the double layer was only about 57 per cent of the input for the same number of turns in a single layer. This again is caused primarily by the larger volume of steel in close proximity to the winding when the latter is better distributed. In short, the winding should be arranged in such a manner as to enclose as much as possible of the metal to be heated. It should be wound in one layer and it should be applied as close to the vessel as structural limitations and the necessity for adequate thermal insulation of the vessel will permit.

Effect of temperature will next be considered. As the electrical resistivity of iron, which increases with the temperature is a factor in both the eddy current heating and the induced secondary current heating, they being inversely proportional to it, the increase in temperature of the chemical vessel will result in a decrease in the electrical input without changing any other variables. With high temperatures this decrease is sufficient to be a factor in design. In some installations the input at a temperature of 400 deg. C. is only 50 to 60 per cent of that at room temperature; in others it is 70 per cent. The variation cannot be quantitatively explained at this time. The result is that it becomes necessary to increase the initial rate to compensate for the subsequent drop. Power input at operating temperature should be multiplied by a factor in order to secure the starting input which must be designed for. Until a more complete knowledge becomes available a factor of 1.0 may be used at 25 deg. C.; 1.1 at 100 deg.; 1.3 at 200 deg.; 1.5 at 300 deg.; and 1.8 at 400 deg. C.

The last variable to be fixed is the number of turns. This is at once the most difficult and the simplest part of the design; the most difficult because it cannot be exactly and readily predicted from one installation to another, and the simplest because it has the least ultimate effect on the usefulness and efficiency of the heater. Table IV shows the effect of changing the number of turns in one installation. Between the limits shown the input was inversely proportional, about 1.54 power of



Induction heating installations A, F, and G in Table I

the turns. Unfortunately, for some other installation it will be different. A qualitatively similar variation, however, will be encountered. Effect of voltage on heat input is also shown in the same table. The power input varied approximately as the 2.29 power of the applied voltage.

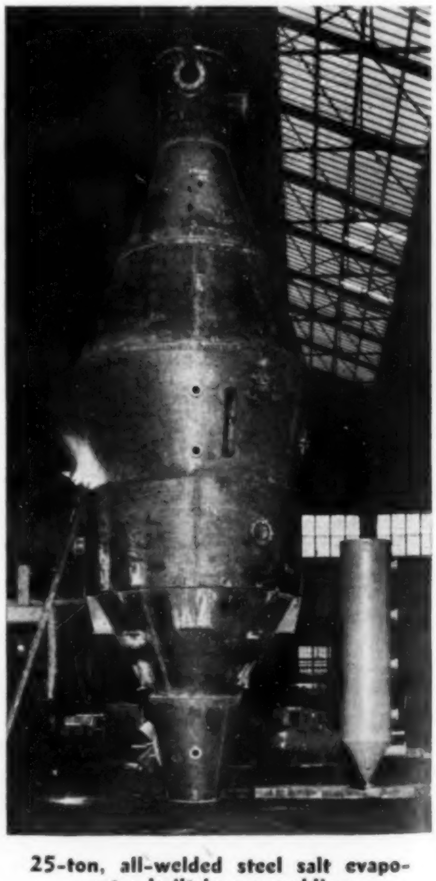
If an attempt is made to expand this relationship as a basis for design of other installations it is found that the effect of the minor variables together with varying steel core dimensions precludes any success. One fact stands out; namely, the number of turns does not vary so widely as to make plant scale experimentation unfeasible. The undesirable consequences of a poor guess as to the required number of turns are not of sufficient importance to constitute a serious handicap to the use of induction heating. If the wire size is selected amply large for the anticipated load the problem resolves itself into one of simply trying a few turns of wire and by addition or subtraction arriving at the correct number. In other words, if the preliminary design is well done, the economic effect on the job of changing the actual number of turns is not serious. If it is desired to reduce the number of turns, it is a simple matter to add taps to the winding. Once the wire size, the general winding arrangement, the source of electrical supply, and the method of supporting and insulating the winding have been fixed by the design engineer, the determination of the actual number of turns can readily be left to the field electrician. The latter, armed with a wattmeter, a supply of wire, and a few extra fuses can without difficulty arrive at the correct number of turns if given a general idea of what to accomplish.

A few mechanical details remain to be considered. The wire is usually asbestos insulated in the smaller sizes and wrapped directly on the thermal lagging without other support. In the larger installations the cost of asbestos covered wire becomes excessive and bare wire should be used. In this case, the wire must be supported on suitable insulating spacers between. The wire and spacers being outside the thermal insulation need not be resistant to extremely high temperatures. The first and last turns should not be clamped back on themselves for mechanical security in such a manner that an electrical contact is made. If this is done a heavy current will flow in the short circuited turn which will not only be wasted, but which will cause serious overheating of the turn. No undue mechanical stresses or vibration will be encountered on the winding provided it is located reasonably symmetrically with respect to the vessel. Particularly when bare wire is used a shield or guard is usually constructed around the vessel if it is in the open. This guard must not be of metal even if it is made non-continuous around the vessel; otherwise, heating of the guard will occur. Reasonable isolation of supporting steelwork must be maintained or it will also be heated. One to two feet, depending on the arrangement, is usually sufficient.

All-Welded Steel Evaporator

An EXAMPLE of the increasing sphere of welding is the fabrication of three all-welded steel salt evaporators designed by Clinton S. Robison & Associates, built by Wellman Engineering Co. and erected at the St. Clair, Mich., plant of the Diamond Crystal Salt Co. These are the first such evaporators built in the United States and supersede the sectionalized cast iron type which has been used since the early days of the salt industry. The change in design was prompted solely by an economic standpoint. Use of rolled steel with its increased strength over cast iron, reduction of weight of approximately 40 per cent, elimination of expensive machining operations of facing and drilling connecting flanges, elimination of bolts and gaskets, and difference in the price of castings and rolled plate, permit a fabricating cost considerably lower than that possible with a cast design. In addition to these advantages, evaporators can be nearly 100 per cent shop fabricated including assembly of the agitator, shaft and bearings. The liability of leaky joints is entirely eliminated with welded construction. The field erection, in handling one nearly completed unit instead of assembling many sections, materially reduces this important item of cost. From the standpoint of structural strength, lighter plate would have been ample, but heavier plate was used to withstand the corrosive action of the brine.

The evaporators were fabricated in sections. All longitudinal seams were made first and the conical sections above and below the cylindrical condenser were alternately welded circumferentially. After welding each conical section longitudinally, it was necessary to round them up on a hydraulic press due to the flattening effect of the welds.



25-ton, all-welded steel salt evaporator built by arc welding

Accident Frequency Rate for the Chemical Industry Declines

THE 1934 accident frequency rate for the chemical industry is five per cent lower than that of 1933, but the severity rate is six per cent higher, according to figures of the National Safety Council, based on reports from 254 plants, whose employees worked 217,509,000 man-hours. These figures, just issued, show that these plants averaged 10.30 for frequency, in comparison with 15.29 for all industries, and 1.81 for severity, in comparison with 1.70.

The injury frequency rate is based on the number of disabling injuries per million man-hours of work, while the severity rate is determined by the number of days lost through disabling injuries, per 1,000 man-hours of work.

On the basis of the Council's figures, chemical plants tied with non-ferrous metal plants for the ninth lowest place in frequency of accidents in a list of 30 major industries, and twentieth in severity.

Since 1926, the frequency of disabling injuries has decreased 58 per cent in the chemical industry in comparison with a reduction of 57 per cent for all industries. In severity, however, the decrease in rate is only twelve per cent against 37 per cent for all industries.

In 1934, large units had the lowest frequency rates, but were out-stripped by small plants on the basis of severity. However, when the records of change from 1933 to 1934 are compared, large plants have better records than small ones. The experience is shown:

Size Group.	1934 Frequency Rate	1934 Severity Rate	1933–1934 Change in Frequency Per Cent	1933–1934 Change in Severity Per Cent
Large	9.02	1.96	Dec. 5	Inc. 17
Middle sized.	13.34	.89	Dec. 26	Dec. 50
Small	15.91	1.05	Dec. 8	Inc. 141

Among the various kinds of plants, 1934 injury rates were lowest in those manufacturing carbon products. These plants averaged 4.04 for frequency and 0.31 for severity. Further comparisons may be obtained from this table:

Industrial Group	1933–1934 Change in Frequency Per Cent	1933–1934 Change in Severity Per Cent
Pharmaceutical and Fine Chemical Manufacturing	Dec. 22	Inc. 231
Vegetable Oil Manufacturing	Dec. 20	Inc. 80
Soap Manufacturing	Dec. 19	Inc. 136
Not Otherwise Classified	Dec. 5	Dec. 39
Dye Manufacturing	Inc. 11	Dec. 46
Paint and Varnish Manufacturing	Inc. 13	Dec. 78
Explosives Manufacturing	Inc. 53	Inc. 39
Coal Tar Distillers	Inc. 67	Inc. 140

Twenty-four chemical units were cited by the National Safety Council for outstanding safety records during the year. The list follows:

Acid Manufacturing

Standard Wholesale Phos. and Acid Works. Lowest 1934 severity rate among large units—0.10.

Manufacture of Carbon Products

Union Carbide Co. The Niagara Falls plant of the National Carbon Co., a subsidiary, worked more hours without a disabling injury than any other large unit with a perfect 1934 record—818,000. The Clarksburg, West Virginia plant, also of the National Carbon Co., has the largest 1934 exposure without a disabling injury among small units—149,000.

Chlorine and Alkali Manufacturing

Charles Lennig and Co. Best 1934 record among large units—894,000 man-hours without a disabling injury; also the largest improvement since 1932 in both injury rates—100 per cent due to its perfect 1934 record.

Coal Tar Distillers

Koppers Products Co. The Woodward, Alabama, plant has the lowest 1934 frequency rate among large units —17.44. The Providence, R. I., plant has the lowest 1934 severity rate among large units—0.04. The New Haven, Conn., plant worked 27,000 man-hours during 1934 without a disabling injury and thereby reduced frequency and severity 100 per cent since 1932.

Inland Tar Co. Worked more hours without a disabling injury than any other unit with a perfect 1934 record—39,000.

Explosives Manufacturing

Canadian Industries, Ltd. The McMasterville plant has the lowest 1934 severity rate among large units—0.15. The Nobel plant worked more hours without a disabling injury than any other small unit with a perfect 1934 record—242,000.

Trojan Powder Co. The Roberts, California, plant worked 132,000 man-hours during 1934 without a disabling injury and thereby reduced both injury rates 100 per cent since 1932.

Fertilizer Manufacturing

Canadian Industries, Ltd. The McMasterville plant worked more hours without a disabling injury than any other unit with a perfect 1934 record—65,000 and thereby reduced both injury rates 100 per cent since 1932.

Manufacture of Industrial Gases

Union Carbide Co. The Diamond, West Virginia, plant has the best 1934 record among large units by working 108,000 man-hours without a disabling injury.

Carbo-Oxygen Co. The Bayonne, New Jersey, plant worked more hours without a disabling injury than any other small unit with a perfect 1934 record—30,000. The Chicago, Illinois, plant is the largest small unit to achieve a perfect 1934 record and thereby reduce both injuries 100 per cent since 1932.

Paint and Varnish Manufacturing

Western Electric Company, Inc. The Chemical Division has the lowest 1934 severity rate among large units—0.02.

Carpenter-Morton Co. Largest small unit to achieve a perfect 1934 record—112,000 man-hours and thereby reduce both injury rates 100 per cent since 1932.

Manufacture of Plastics

Canadian Industries, Ltd. The Toronto plant has the best 1934 record by working 261,000 man-hours without a disabling injury.

Salt Manufacturing

Diamond Crystal Salt Co. Lowest 1934 frequency rate among large units —6.96.

Morton Salt Co. The Grand Saline, Texas, plant has the lowest 1934 severity rate among large units—0.21. The Newark, California, plant has the best 1934 record among small units—152,000 man-hours without a disabling injury; also the largest improvement since 1932—100 per cent in both injury rates due to a perfect 1934 record.

Soap Manufacturing

Lever Brothers Co. The Hammond, Indiana, plant has the lowest 1934 frequency rate among large units—3.41.

Los Angeles Soap Co. Lowest 1934 severity rate among large units—0.13.

Vegetable Oils

Procter and Gamble Co. The Little Rock plant of the Buckeye Cotton Oil Co., a subsidiary, has the best 1934 record among large units—165,000 man-hours without a disabling injury; also the largest improvement since 1932—100 per cent in both injury rates due to its perfect 1934 record.

Ralston Purina Co. The Lafayette, Indiana, plant worked more hours without a disabling injury than any other small unit with a perfect 1934 record—22,000.

Chemical Engineer's BOOKSHELF

Factual Economics

Facts About Unemployment Compensation. Prepared by Committee on Social Legislation. 10 pages. Facts About Old Age Security. Prepared by Committee on Social Legislation. 19 pages. Thirty-Hour Week. Prepared by Committee on Labor Problems. The Securities Act of 1933 and Its Effect on Financing. Prepared by Committee on Financial Legislation of the National Conference of Business Paper Editors. 26 pages. Copies available without charge through the Associated Business Papers, Inc., 330 West 42d St., New York City.

THIS series of factual studies dealing with current economic problems of major interest to industry represents an effort on the part of business paper editors to present their findings totally uncolored and free from any bias. The purpose was primarily to serve the member publications of A.B.P. with basic information that would be helpful in determining editorial programs and policies. However, the series has awakened wide interest among readers of business papers and arrangement has lately been made for a limited distribution to companies and libraries where these national problems are being studied. This series of pamphlets is commended for their reference value.

Alchemical Engineering

Alchemy Child of Greek Philosophy. By *Arthur John Hopkins*. Columbia University Press, New York. 262 plus XI pages. Price, \$3.50.

Reviewed by *Paul D. V. Manning*

DEPENDENCE of all historical works on the building up of a structure of corroborated facts is nowhere better illustrated than by the history of alchemy. Although the beginning of alchemy scarcely dates back to the first century A. D., it is so difficult to gather authentic facts, that it has not been possible heretofore to interpret and connect these facts into a history.

Professor Hopkins has coordinated the facts which his years of study have brought forth, with those classified by others. These he has considered in the light of Greek philosophy and contemporary history. The result is a credible history of alchemy which is interesting.

The first chapters survey the available knowledge and then trace the influence of Greek philosophy, Alexandrian religion, Egyptian civilization and imitative arts. Alchemy was born in Egypt, centered mostly in Alexandria, where the skill in mechanical arts attained by the Egyptians was the motivating factor.

The author next discusses the alchemical literature, transmutation, the gradual transition of alchemy to the other nations, more important in later civilization. The final transmutation of alchemy into chemistry was accomplished mainly through the work of Berthelot and his interpretations of the work of others. Several appendices give copies of translations.

"Alchemy Child of Greek Philosophy" is a well ordered history of alchemy, nicely written and well worth reading by chemical engineers.

Post-Graduate Formulae

The Chemical Formulary. Vol. II. Edited by *H. Bennett*. Published by D. Van Nostrand Co., New York. 570 pages. Price, \$6.

Reviewed by *J. R. M. Klotz*

THE LATE Edgar F. Smith—than whom no dearer soul ever existed in the profession of Chemistry—used to say that everyone in the field of Chemistry should take a post-graduate course of at least one year every seven years.

The publishers of "The Chemical Formulary" are giving us our post graduate course within a year. Approximately one year ago the writer went through their Volume I of The Chemical Formulary with considerable interest and no little pleasure and surprise, and we now find that we have been digesting what might be termed an advanced course in chemical formulation. We note a considerable improvement in the employment of what might be termed "Patent Examples," which we pointed out last year might not be received enthusiastically by the owners of certain patents. The editors in this edition have attempted to state a little more clearly that the experimenter, according to the formulae that they give, must make sure that he is not infringing patented intellectual property.

On the whole, the book is very well worth while. We believe that a number of people can secure quite a running start on the solution of some of their problems by using this sort of thing as a basis of experimental work to solve their specific problems. The book is of very neat appearance, good print and very readable and contains a very limited number of errors, which are apt to creep into this sort of compendium.

Combating Corrosion

Corrosion, Causes and Prevention. By *Frank N. Speller*. Second Edition. McGraw-Hill Book Co., New York. 694 pages. Price, \$7.

Reviewed by *B. H. Strom*

MANY experimental data in regard to the world-wide problem of corrosion have become available since the first appearance of this monograph, almost ten years ago. The form of treatment and classification of factors and types of corrosion used in the first edition have been maintained in this volume, but many of the sections have been condensed or omitted where better data are now available. For certain subjects the old edition may therefore still be useful for reference in conjunction with this edition.

With the general acceptance of the electrochemical theory of corrosion in the presence of water, the mechanism of corrosion has been treated on this basis. Important revisions are found in the chapters dealing with factors internal and external to metals, and with methods of testing; these have been largely rewritten in the light of recent experience. Much new knowledge on the subject of soil corrosion and protective coatings for use underground has also been incorporated, and the bibliography has been brought up to date. The reader will undoubtedly find the book, in its present form, one of the most advanced, inclusive, and authoritative on a subject of broad interest to chemical engineers.

The Book of Stainless Steels. Edited by *Ernest F. Thum*. Second Edition. Published by American Society for Metals, Cleveland, Ohio. 787 pages. Price, \$5.

NOTHING could better indicate the wide endorsement of this book than the need for a second edition slightly more than a year after its first appearance. Each of the 82 contributors has been given the opportunity to revise his material. As a result 22 of the chapters have been thoroughly revised or entirely rewritten, and no less than 161

pages have been added. Among the new material, that found in the chapters on requirements of the petroleum refineries and on chromium nickel castings should be of particular importance to *Chem. & Met.* readers. With the great interest in stainless steels the world over the success of the second edition should be assured.

ALLOYS OF IRON AND COPPER. By *J. L. Gregg* and *B. N. Daniloff*. Alloys of Iron Research Monograph Series. Published for the Engineering Foundation by McGraw-Hill Book Co., New York. 454 pages. Price, $5.

THE PURPOSE of this monograph is to present in ready form the important facts on copper steels and other alloys of iron and copper, much of which has never before appeared in book form. Over 600 pertinent articles on the subject have been studied, of which abstracts have been made. Of particular interest are the numerous investigations of the effect of small additions of copper on the corrosion resistance of iron. Liberal use of reference numbers in the text assist the reader in going back to the original texts when desired. Some reference has been made to patents, although no complete study of the patent literature has been attempted.

DESIGN AND CONSTRUCTION OF HIGH PRESSURE CHEMICAL PLANT. By *Harold Tongue*. Published by D. Van Nostrand Co., New York. 420 pages. Price, $12.

THIS EDITION conforms in every detail with the English edition which was reviewed by Norman W. Krase in our issue of July, 1934.

TRANSACTIONS OF THE ELECTROCHEMICAL SOCIETY. VOL. 63, 1933. Proceedings of Sixty-Third General Meeting. Published by the Society at Columbia University, New York. 466 pages. Price, $6.50.

CONTAINS a series of papers on the electrolysis of aqueous electrolytes and one on the electric furnace and its products.

TRANSACTIONS OF AMERICAN INSTITUTE OF CHEMICAL ENGINEERS. VOL. 29, 1933. Published by the Institute and sold by D. Van Nostrand Co. New York. 346 pages. Price, $6.

CONTAINS papers presented at Chicago, June 14-16, 1933.

TRANSACTIONS OF AMERICAN INSTITUTE OF CHEMICAL ENGINEERS. VOL. 30, 1933-34. Published by the Institute and sold by D. Van Nostrand Co., New York. 661 pages. Price, $6.

CONTAINS papers presented at Roanoke, Va., Dec. 12-14, 1933, and New York City, May 14-16, 1934.

STATISTICAL APPENDIX TO MINERALS YEARBOOK 1932-33. Edited by *O. E. Kiessling*. Published by U. S. Bureau of Mines, Washington, D. C. For sale by Superintendent of Documents. 514 pages. Price, $1.

FOR CONVENIENCE the final statistics for the specific mineral commodities have been compiled in a single reference volume. Some of the data not complete in the Yearbook have been revised and supplemented by final tables.

Chemical Reviews

ANNUAL SURVEY ON AMERICAN CHEMISTRY. Vol. IX. By *Clarence J. West*. Published for the National Research Council by Reinhold Publishing Corp., New York. 396 pages. Price, $4.50.

ANNUAL REPORTS ON THE PROGRESS OF CHEMISTRY. Vol. XXXI. Edited by *Clarence Smith*. Published by The Chemical Society, London. 442 pages.

ANNUAL REPORTS ON THE PROGRESS OF APPLIED CHEMISTRY. Vol. XIX. Edited by *T. F. Burton*. Published by Society of Chemical Industry, London. 836 pages. Price, 7s. 6d. to members; to others, 12s. 6d.

EXCEPT FOR the omission of the chapter on biochemistry no changes have been made in the general outline of the Annual Survey of American Chemistry. Of the 25 topics covered in this survey twelve may be considered as devoted to industrial topics; these chapters do not only give the trends in the industry but also the accomplishments of the period covered.

In the "Annual Reports on the Progress of Chemistry" which maintains the high standard of the former volumes we find a review of British work as well as of progress made in other fields. Much of the space is devoted to organic chemistry. The critical nature of these reports add to their value.

The field of applied chemistry is very well covered in the report by the Society of Chemical Industry. This volume contains a large amount of material and gives a good picture of industrial chemical developments during the period under consideration.

HANDBOOK OF CHEMISTRY AND PHYSICS, NINETEENTH EDITION. Edited by *C. D. Hodgman*. Published by Chemical Rubber Publshing Co., Cleveland, Ohio. 1934. 1,933 pages. Price, $6.

ONE of the more important additions to this edition of this famous handbook is a collection of X-ray data for more than 1,300 elements and compounds. The thermodynamic properties of ammonia and other refrigerants have also been given in detail. A new form of table for determining the density of moist air offers a quick method of obtaining this quantity from the temperature, pressure, and dew point with sufficient accuracy for most purposes. Many other tables have ben completely revised and new ones added. To facilitate the use of the handbook colored index pages have been inserted at several points, thus dividing the book into sections.

VARNISH MAKING. By *T. Hedley Barry* and *George William Dunster*. Leonard Hill, Ltd., London, England. 132 pages. Price, 10s. 6d.

MUCH advance has been made in the art of varnish making during recent years. New raw materials have been introduced, particularly synthetic resins and China wood oil, and new methods of heating and heat transfer have been adopted. The present volume which is written principally for the student has devoted a chapter to each of the important raw materials. Up-to-date processes and equipment have been described, and practical examples given for the various types of varnishes. A chapter on laboratory testing includes details of the simpler chemical tests, with particular attention to the practical and physical tests of most immediate importance.

NEW FEDERAL ORGANIZATIONS. By *Laurence F. Schmeckebier*. Published by the Brookings Institution, Washington, D. C. 199 pages. Price, $1.50.

AN OUTLINE of 46 major organizations and numerous subsidiary corporations created by the present Administration between March 4, 1933, and June 30, 1934, to deal with the problem of depression, is presented in this volume. While most of these organizations are concerned with new policies, a few have resulted from the normal growth of government activities. The scope of each unit, the reason for its creation, the location of field offices, and a brief statistical measure of its activities are given.

A.S.T.M. TENTATIVE STANDARDS, 1934. Published by American Society for Testing Materials, Philadelphia. 1,257 pages. Price, $7, paper; $8, cloth.

OF the 236 tentative standards contained in this volume 25 relate to ferrous metals; 48 to cement, ceramics, concrete, and masonry; 127 cover miscellaneous materials such as paint, petroleum, insulation, and textiles, while 11 are general testing methods applying to these materials.

A.S.T.M. PROCEEDINGS. Vol. 34, Parts I and II. 1,325 and 943 pages.

CONTAINS the proceedings of the 37th Annual Meeting at Atlantic City, June 25-29, 1934.

GERMAN-ENGLISH DICTIONARY FOR CHEMISTS. Second Edition. By *Austin M. Patterson*. John Wiley & Sons, Inc., New York, and Chapman & Hall, London, England. 411 pages. Price, $3.

A GREAT NUMBER of new scientific terms has been added in the new edition of this excellent dictionary, such as a glossary of terms relating to atomic

structure, bringing the total number of entries up to about 42,000. Most users will probably react favorably to the change to the paragraph style for entries beginning with the same word element, whereby much space has been conserved. Readers of German technical literature should find the book a valuable aid in their work.

Die Rationelle Gestaltung der Chemisch-Technischen Produktion. By *Hans Hoppmann*. Verlag Chemie, G.m.b.H., Berlin. 140 pages. Price, 9 Rm.

IN THIS TREATISE on the rationalization of the chemical industries the author has come to the conclusion that, in spite of prevalent public opinion, this is not one of the causes for unemployment. On the contrary, it is one of the means of raising the general standard of living, by making available to the masses a great abundance of consumers' goods, of improved quality and at reduced prices. During the last 10-15 years the German chemical industry has made rapid strides toward better management and control, in the selection of proper raw materials, and in the adoption of scientific methods in production and distribution. This development has been illustrated by appropriate examples from industry.

Ice Cream Abstracts

Abstracts of Literature on the Manufacture and Distribution of Ice Cream. Vol. V, 1931-1933. International Association of Ice Cream Manufacturers, Barr Building, Washington, D. C. 118+XIV pages. Price, $5.

Reviewed by *L. W. Bass*

IN 1927 the International Association of Ice Cream Manufacturers established an abstracting service for the benefit of its members. This service has been an indispensable aid to the dairy chemist, for the original literature on ice cream and related products is not readily available except in the larger laboratories specializing in these subjects. The abstracts are prepared under the direction of A. C. Dahlberg, with the editorial cooperation of the Research Committee of the Association.

Vol. V, covering the literature for 1931-1933, contains over 300 abstracts. Not only are the commercial aspects of manufacture and distribution covered, but also the literature of the basic sciences—chemistry, physics, bacteriology, and nutrition—is thoroughly reviewed. In addition to subject and author indexes, a useful tabular appendix of information on ice cream has been included.

There is no comparable source of information on ice cream. This series of books, invaluable to the dairy chemist, should also be in every chemical library having contact with the industry.

Die Chemische Analyse. Vol. 33, Neuere Massanalytische Methoden. By *E. Brennecke, K. Fajans, N. H. Furman*, and *R. Lang*. Ferdinand Enke, Stuttgart, Germany. 211 pages. Price, 18 Rm.

RECENT volumetric methods of analysis are treated in this volume. The chapters include the use of cerium sulphate as an oxidizing agent, iodate and bromate methods, reduction by chromous salt solutions, oxidation-reduction indicators, and adsorption indicators in precipitation titrations.

Schwebstoffe in Gasen. By *August Winkel* and *Gerhart Jander*. Ferdinand Enke, Stuttgart, Germany. 116 pages. Price, 7.50 Rm.

A STUDY of colloidal suspensions in gaseous media, with discussion of the principal factors influencing systems of this type, such as concentration, temperature, gas pressure, viscosity, and particle size. Industrial applications have been treated briefly.

Physikalische Chemie der Eisenhüttenprozesse. Vol. II. By *H. Schenck*. Julius Springer, Berlin. 274 pages. Price, 28.50 Rm.

PRODUCTION of steel has been taken up in the second volume of Dr. Schenck's excellent handbook. The physical chemistry underlying the metallurgical processes in iron and steel production has been subjected to an intensive study during the last decade, and the author has presented an exhaustive review of the progress made, in the laboratory as well as in the technical operations.

GOVERNMENT PUBLICATIONS

Documents are available at prices indicated from Superintendent of Documents, Government Printing Office, Washington, D. C. Send cash or money order; stamps and personal checks not accepted. When no price is indicated pamphlet is free and should be ordered from bureau responsible for its issue.

World Chemical Developments in 1934, by C. C. Concannon and A. H. Swift. Bureau of Foreign and Domestic Commerce Trade Information Bulletin 823; 10 cents.

Fuel and Power in Japan, by John R. Bradley and Donald W. Smith. Bureau of Foreign and Domestic Commerce Trade Information Bulletin 821; 5 cents.

Matches. Tariff Commission Report No. 94, Second Series; 5 cents. Résumé of information on production, sales, and numerous trade aspects.

Quicksilver. Tariff Commission Report No. 92, Second Series; 5 cents. Report to the President under the provisions of Section 3 (e) of the National Industrial Recovery Act.

Beer. Tariff Commission Report No. 98, Second Series; 5 cents. Report to the President on difference in costs of production of beer in the U. S. and in principal competing country, with supplementary report and proclamation by the President.

Whisky, Wine, Beer, and Other Alcoholic Beverages and the Tariff. Tariff Commission Report No. 90, Second Series; 10 cents.

Regulations Relating to False Advertising and Misbranding of Distilled Spirits. Federal Alcohol Control Administration, issued May 13, 1935 (with appendices).

Standards for Paper Towels, by Burdon W. Scribner and Russell W. Carr. Bureau of Standards Circular 407; 5 cents.

Chip Board, Laminated Chip Board, and Miscellaneous Boards for Bookbinding Purposes. Bureau of Standards, Commercial Standard CS49-34; 5 cents.

Papermaking Quality of Cornstalks. by Charles G. Weber and others. Bureau of Standards Miscellaneous Publication 147; 5 cents.

Fuel Oils. Bureau of Standards Commercial Standard CS12-35 (third edition); 5 cents.

Revised Indexes of Factory Employment and Pay Rolls 1919 to 1933. Bureau of Labor Statistics Bulletin 610; 10 cents.

Variations in Wage Rates Under Corresponding Conditions, by Mary Elizabeth Pidgeon. Department of Labor Women's Bureau Bulletin 122; 10 cents.

Review of Literature on Effects of Breathing Dusts With Special Reference to Silicosis, by D. Harrington and Sara J. Davenport. Bureau of Mines Information Circular 6835; mimeographed. Contains chapters on definition and classification of dusts; sources of exposure to dusts; physiological effects of breathing dusts.

Effects of the Inhalation of Asbestos Dust on the Lungs of Asbestos Workers, by A. J. Lanza and others. Public Health Service Reprint No. 1665; 5 cents.

Chemical Studies of Infertile Soils Derived From Rocks High in Magnesium and Generally High in Chromium and Nickel, by W. O. Robinson and others. Department of Agriculture Technical Bulletin 471; 5 cents.

Relation Between the Chemical Composition of Citrus Scale Insects and Their Resistance to Hydrocyanic Acid Fumigation, by A. R. C. Haas. Reprint from Journal of Agricultural Research, Vol. 49, No. 6, Sept. 15, 1934, Key No. Calif.-68; 5 cents.

The Rubber Content of Two Species of Cryptostegia and of an Interspecific Hybrid in Florida, by Loren G. Polhamus and others. Department of Agriculture Technical Bulletin 457; 10 cents.

Boron in Soils and Irrigation Waters and Its Effect on Plants With Particular Reference to the San Joaquin Valley of California, by Frank M. Eaton. Department of Agriculture Technical Bulletin 448; 20 cents.

Index to Publications of the United States Department of Agriculture, 1926-1930, compiled by Mary A. Bradley. 694 pages, buckram, $1.50.

Biological Products. Public Health Service Reprint 1667; 5 cents. Establishments licensed for the propagation and sale of viruses, serums, toxins, and analogous products.

Manual of First-Aid Instruction. Bureau of Mines unnumbered document; 20 cents.

Supplement to List of Publications of the Bureau of Mines, July 1, 1933 to June 30, 1934.

Study of Mine Roof in the Coking District of Western Pennsylvania, by J. W. Paul and L. N. Plein. Bureau of Mines Technical Paper 563; 5 cents.

Carbonizing Properties and Constitution of Alma Bed Coal From Spruce River No. 4 Mine Boone County, W. Va., by A. C. Fieldner and others. Bureau of Mines Technical Paper 562; 10 cents.

Mineral Production Statistics for 1933—Statistical appendices from the 1934 Minerals Yearbook on: Ore Concentration; Natural Gas; Cement; 5 cents each.

Cotton Goods. Census of Manufactures, 1933, Bureau of the Census; mimeographed. A special compilation of cotton textile statistics, including data on bags, other than paper, not made in textile mills; dyeing and finishing textiles; house-furnishing goods not elsewhere classified; and miscellaneous articles made of textiles.

Your Plant NOTEBOOK

SENSIBLE MOLAL HEAT CONTENT OF GASES AT HIGH TEMPERATURES

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SEVERAL YEARS ago, Eastman (Bur. of Mines Bull. 445, 1929) made a critical survey of the experimental data on the specific heats of gases at high temperatures, from which he derived a series of empirical equations for the molal specific heats at constant pressure. Following the publication of these equations they were used as the basis of charts (see Halferdahl, *Chem. & Met.*, **37**, 1930, p. 686) for the ready determination of specific heats. It has been the author's belief, however, that a tabulation, at frequent temperature intervals, of the molal heat contents of the principal gases met in high temperature work would be more convenient to use. This has been done.

The first operation was to convert the original equations into a form in which the temperature factor was in degrees Rankine (absolute F.) rather than degrees Kelvin (absolute C.). After proper modification, formal integration and insertion of the lower temperature limit, 520 deg. R. (60 deg. F.), Eastman's equations appear as follows:

CO_2: $7.70T_2 + 1.47\dot{2} \times 10^{-3}T_2^2 - 8.5391 \times 10^{-8}T^3 - 4390.0823$

N_2, O_2 CO: $6.76T_2 + 1.683 \times 10^{-4}T_2^2 + 1.33745T_2^3 - 3562.5978$

H_2O: $8.22T_2 + 4.1\dot{6} \times 10^{-5}T_2^2 + 1.3786 \times 10^{-7}T_2^3 - 4305.051$

H_2: $6.85T_2 + 7.777\dot{7} \times 10\ {}^{5}T_2^2 + 2.26 \times 10^{-8}T_2^3 - 3586.21$

CH_4: $5.90T_2 + 2.66 \times 10^{-3}T_2^2 - 3789.07$

where T_2 is any value of Rankine temperature used as the upper limit of integration.

From these equations the values of the sensible heats per pound-mol. were computed by synthetic substitution in a calculating machine. The results were computed to four decimal places and examined by the method of differences to the third decimal place and finally were rounded off at the first decimal place. While every effort has been made to check the values reported, it seems probable that some errors may have been made. Due notice of these will be appreciated.

Grateful acknowledgment is made for the valuable assistance rendered by Prof. Irwin Roman and by C. M. Marquardt, of the Mathematics Department of this institution, in the preparation of these tables.

Below are tabulated the sensible molal heats in B.t.u. per pound-mol. for carbon dioxide, nitrogen, oxygen, carbon monoxide, water vapor, hydrogen and methane, from 520 deg. R., up.

The tables are useful in various ways: They immediately give the sensible heat content of any of the tabulated gases above 520 deg. R. By subtraction they may be used to determine the heat eontent of any of the gases between any two temperatures above 520 deg. R. By suitable interpolation sensible heat contents below 520 deg. R. may be estimated well within the limits of accuracy of the original equations. Mean specific heat in any interval may be obtained by dividing the sensible heat content through the interval by the temperature interval in degrees F. Finally, interpolation within any 10-deg. interval in the table may be made, within the limits of accuracy of the original equation, by the same method employed in interpolating logarithms and other tabular data.

Sensible Heat Content of Gases, 520-1500 Deg. R., B.t.u. per Pound-Mol.

Temp. Deg. R.	CO_2	N_2, O_2, CO	H_2O	H_2	CH_4
530	91.8	69.5	83.8	69.5	87.0
540	183.8	139.0	167.6	139.0	174.5
550	276.1	208.5	251.5	208.6	262.6
560	368.6	278.1	335.4	278.1	351.2
570	461.4	347.8	419.4	347.7	440.3
580	554.5	417.4	503.5	417.4	530.0
590	647.9	487.1	587.6	487.1	620.2
600	741.5	556.9	671.7	556.7	710.9
610	835.4	626.7	755.9	626.4	802.2
620	929.5	696.5	840.2	696.1	894.0
630	1023.9	766.4	924.6	765.8	986.3
640	1118.6	836.3	1009.0	835.6	1079.2
650	1213.5	906.2	1093.4	905.4	1172.5
660	1308.7	976.2	1177.9	975.2	1266.5
670	1404.1	1046.2	1262.5	1045.0	1361.0
680	1499.8	1116.3	1347.2	1114.9	1456.0
690	1595.8	1186.3	1431.9	1184.7	1551.5
700	1692.0	1256.5	1516.7	1254.7	1647.6
710	1788.5	1326.6	1601.5	1324.6	1744.2
720	1885.2	1396.9	1686.4	1394.5	1841.3
730	1982.2	1467.1	1771.4	1464.5	1939.0
740	2079.5	1537.4	1856.4	1534.5	2037.2
750	2177.0	1607.7	1941.5	1604.6	2135.9
760	2274.8	1678.1	2026.7	1674.6	2235.2
770	2372.8	1748.5	2112.0	1744.7	2335.0
780	2471.1	1818.9	2197.3	1814.8	2435.3
790	2569.6	1889.5	2282.7	1885.0	2536.2
800	2668.4	1959.9	2368.2	1955.1	2637.6
810	2767.5	2030.6	2453.8	2025.3	2739.5
820	2866.8	2101.2	2539.4	2095.5	2842.0
830	2966.3	2171.8	2625.1	2165.8	2945.0
840	3066.1	2242.5	2710.9	2236.1	3048.5
850	3166.2	2313.2	2796.7	2306.4	3152.6
860	3266.5	2384.0	2882.7	2376.7	3257.2
870	3367.0	2454.8	2968.7	2447.6	3362.3
880	3467.8	2525.7	3054.8	2517.4	3468.0
890	3568.9	2596.6	3140.9	2587.8	3574.2
900	3670.2	2667.5	3227.2	2658.3	3680.9
910	3771.7	2738.5	3313.5	2728.7	3788.2
920	3873.5	2809.5	3400.0	2799.2	3896.0
930	3975.6	2880.6	3486.5	2869.7	4004.3
940	4077.8	2951.7	3573.1	2940.3	4113.2
950	4180.4	3022.8	3659.8	3010.9	4222.6
960	4283.2	3093.9	3746.5	3081.5	4332.5
970	4386.2	3165.2	3833.4	3152.1	4443.0
980	4489.5	3236.5	3920.3	3222.8	4554.0
990	4593.0	3307.8	4007.4	3293.4	4665.5
1000	4696.7	3379.1	4094.5	3364.2	4777.6
1010	4800.8	3450.5	4181.7	3434.9	4890.3
1020	4905.0	3521.9	4269.0	3505.7	5003.3
1030	5009.5	3593.4	4356.4	3576.5	5117.0
1040	5114.2	3664.9	4443.9	3647.3	5231.2
1050	5219.2	3736.5	4531.5	3718.2	5345.9
1060	5324.4	3808.1	4619.2	3789.1	5461.2
1070	5429.9	3879.7	4706.9	3860.0	5577.0
1080	5535.6	3951.4	4794.8	3938.0	5693.3
1090	5641.5	4023.1	4882.8	4001.9	5810.2
1100	5747.7	4094.9	4970.9	4072.0	5927.6
1110	5854.1	4166.7	5059.0	4144.0	6045.5
1120	5960.7	4238.5	5147.3	4215.1	6164.0
1130	6067.6	4310.4	5235.7	4286.2	6283.0
1140	6174.7	4382.4	5324.1	4357.4	6402.5
1150	6282.1	4454.4	5412.7	4428.5	6522.6
1160	6389.7	4526.4	5501.4	4499.7	6643.2
1170	6497.5	4598.5	5590.2	4571.0	6764.3
1180	6605.5	4670.6	5679.1	4642.2	6886.0
1190	6713.8	4742.7	5768.1	4713.5	7008.2
1200	6822.4	4814.9	5857.2	4784.8	7130.9
1210	6931.1	4887.2	5946.4	4856.2	7254.2
1220	7040.1	4959.4	6035.7	4927.6	7378.0
1230	7149.3	5031.8	6125.1	4999.0	7502.3
1240	7258.8	5104.1	6214.7	5070.5	7627.2
1250	7368.5	5176.5	6304.3	5142.0	7752.6
1260	7478.4	5249.0	6394.1	5213.5	7878.5
1270	7588.6	5321.5	6483.9	5285.0	8005.0
1280	7698.9	5394.0	6573.9	5356.5	8132.0
1290	7809.5	5466.6	6664.0	5428.2	8259.5
1300	7920.4	5539.2	6754.2	5499.9	8387.6
1310	8031.4	5611.9	6844.6	5571.6	8516.2
1320	8142.7	5684.7	6935.0	5643.3	8645.3
1330	8254.2	5757.4	7025.6	5714.8	8775.0
1340	8366.0	5830.2	7116.3	5786.6	8905.2
1350	8477.9	5903.1	7207.1	5858.6	9035.9
1360	8590.1	5976.0	7298.0	5930.5	9167.2
1370	8702.6	6048.9	7389.0	6002.4	9299.0
1380	8815.2	6121.9	7480.2	6074.3	9431.3
1390	8928.1	6194.9	7571.5	6146.2	9564.2
1400	9041.2	6268.0	7662.9	6218.2	9697.6
1410	9154.5	6341.2	7754.4	6290.3	9831.5
1420	9268.0	6414.3	7846.1	6362.3	9966.0
1430	9381.8	6487.5	7937.9	6434.4	10101.0
1440	9495.7	6560.8	8029.8	6506.6	10236.5
1450	9609.9	6634.1	8121.8	6578.8	10372.6
1460	9724.4	6707.4	8214.0	6650.9	10509.2
1470	9839.0	6780.8	8306.3	6723.1	10646.3
1480	9953.9	6854.3	8398.7	6795.4	10784.0
1490	10068.9	6927.8	8491.3	6867.7	10922.2
1500	10184.2	7001.3	8584.0	6940.1	11060.9

(Table continued on following page)

Sensible Heat Content of Gases, 1510-2500 Deg. R., B.t.u. per Pound-Mol.

Temp., Deg. R.	CO_2	N_2, O_2, CO	H_2O	H_2
1510	10299.7	7074.9	8676.8	7012.4
1520	10415.5	7148.5	8769.8	7084.9
1530	10531.4	7222.2	8862.8	7157.3
1540	10647.6	7295.9	8956.1	7229.8
1550	10763.9	7369.6	9049.4	7302.3
1560	10880.5	7443.4	9142.9	7374.9
1570	10997.3	7517.3	9236.6	7447.5
1580	11114.4	7591.2	9330.3	7520.1
1590	11231.6	7665.1	9424.2	7592.8
1600	11349.0	7739.1	9518.3	7665.5
1610	11466.7	7813.2	9612.5	7738.2
1620	11584.6	7887.2	9706.8	7811.0
1630	11702.7	7961.4	9801.3	7883.8
1640	11821.0	8035.5	9895.9	7956.7
1650	11939.5	8109.8	9990.7	8029.6
1660	12058.2	8184.0	10085.6	8102.5
1670	12177.1	8258.4	10180.6	8175.5
1680	12296.2	8332.7	10275.8	8248.5
1690	12415.6	8407.1	10371.2	8321.5
1700	12535.1	8481.6	10466.7	8394.6
1710	12654.9	8556.1	10562.3	8467.7
1720	12774.8	8630.7	10658.1	8540.9
1730	12895.0	8705.3	10754.1	8614.1
1740	13015.4	8779.9	10850.1	8687.3
1750	13136.0	8854.6	10946.4	8760.6
1760	13256.7	8929.3	11042.8	8833.9
1770	13377.7	9004.1	11139.4	8907.3
1780	13498.9	9078.9	11236.1	8980.7
1790	13620.3	9153.9	11332.9	9054.1
1800	13741.9	9228.8	11429.9	9127.6
1810	13863.7	9303.8	11527.1	9201.1
1820	13985.7	9378.8	11624.5	9274.7
1830	14107.9	9453.9	11722.0	9348.3
1840	14230.3	9529.0	11819.6	9421.9
1850	14352.9	9604.2	11917.4	9495.6
1860	14475.7	9679.4	12015.4	9569.3
1870	14598.7	9754.7	12113.5	9643.0
1880	14721.9	9830.0	12211.9	9716.9
1890	14845.3	9905.4	12310.3	9790.7
1900	14968.9	9980.8	12408.9	9864.6
1910	15092.7	10056.3	12507.7	9938.5
1920	15216.7	10131.8	12606.7	10012.5
1930	15340.9	10207.4	12705.8	10086.5
1940	15465.3	10282.9	12805.1	10160.5
1950	15589.9	10358.7	12904.6	10234.6
1960	15714.7	10434.4	13004.2	10308.7
1970	15839.6	10510.1	13104.0	10382.9
1980	15964.8	10585.9	13204.0	10457.1
1990	16090.1	10661.8	13304.2	10531.4
2000	16215.7	10737.7	13404.5	10605.7
2010	16341.4	10813.7	13505.0	10680.0
2020	16467.3	10889.7	13605.7	10754.4
2030	16593.5	10965.8	13706.5	10828.9
2040	16719.8	11041.9	13807.5	10903.3
2050	16846.3	11118.0	13908.7	10977.8
2060	16973.0	11194.3	14010.1	11052.4
2070	17099.8	11270.5	14111.7	11127.0
2080	17226.9	11346.8	14213.4	11201.7
2090	17354.2	11423.2	14315.3	11276.4
2100	17481.6	11499.6	14417.4	11351.1
2110	17609.2	11576.1	14519.7	11425.9
2120	17737.1	11652.6	14622.2	11500.7
2130	17865.1	11729.2	14724.8	11575.6
2140	17993.2	11805.8	14827.6	11650.5
2150	18121.6	11882.4	14930.7	11725.4
2160	18250.2	11959.2	15033.9	11800.4
2170	18378.9	12035.9	15137.3	11875.5
2180	18507.8	12112.7	15240.8	11950.6
2190	18636.9	12189.6	15344.6	12025.7
2200	18766.2	12266.5	15448.6	12100.9
2210	18895.7	12343.5	15552.7	12176.1
2220	19025.4	12420.5	15657.0	12251.4
2230	19155.2	12497.6	15761.6	12326.7
2240	19285.2	12574.7	15866.3	12402.1
2250	19415.4	12651.9	15971.2	12477.5
2260	19545.8	12729.2	16076.3	12552.9
2270	19676.3	12806.4	16181.6	12628.4
2280	19807.0	12883.8	16287.1	12704.0
2290	19937.9	12961.2	16392.8	12779.6
2300	20069.0	13038.6	16498.7	12855.2
2310	20200.3	13116.1	16604.8	12930.9
2320	20331.7	13193.6	16711.1	13006.6
2330	20463.3	13271.2	16817.6	13082.4
2340	20595.1	13348.9	16924.3	13158.2
2350	20727.1	13426.6	17031.2	13234.1
2360	20859.2	13504.3	17138.3	13310.0
2370	20991.5	13582.1	17245.6	13386.0
2380	21124.0	13660.0	17353.1	13462.0
2390	21256.6	13737.9	17460.8	13538.1
2400	21389.5	13815.9	17568.7	13614.2
2410	21522.5	13893.9	17676.9	13690.4
2420	21655.6	13971.9	17785.2	13766.6
2430	21789.0	14050.1	17893.7	13842.8
2440	21922.4	14128.3	18002.5	13919.1
2450	22056.2	14206.5	18111.4	13995.5
2460	22190.0	14284.8	18220.6	14071.9
2470	22324.0	14363.1	18330.0	14148.4
2480	22458.2	14441.5	18439.6	14224.9
2490	22592.6	14519.9	18549.4	14301.4
2500	22727.1	14598.5	18659.4	14378.0

Sensible Heat Content of Gases, 2510-5000 Deg. R., B.t.u. per Pound-Mol.

Temp., Deg. R.	CO_2	N_2, O_2, CO	H_2O
2510	22861.8	14677.0	18769.7
2520	22996.6	14755.6	18880.1
2530	23131.6	14834.3	18990.3
2540	23266.8	14912.9	19101.7
2550	23402.1	14991.7	19212.8
2560	23537.6	15070.6	19324.1
2570	23673.3	15149.4	19435.7
2580	23809.2	15228.4	19547.4
2590	23945.2	15307.4	19659.4
2600	24081.3	15386.4	19771.6
2610	24217.6	15465.5	19884.1
2620	24354.1	15544.6	19996.7
2630	24490.7	15623.8	20109.6
2640	24627.5	15703.1	20222.7
2650	24764.5	15782.4	20336.1
2660	24901.6	15861.8	20449.6
2670	25038.9	15941.2	20563.4
2680	25176.3	16020.7	20677.5
2690	25313.9	16100.2	20791.7
2700	25451.7	16179.8	20906.2
2710	25589.6	16259.4	21020.9
2720	25727.6	16339.1	21135.9
2730	25865.8	16418.9	21251.0
2740	26004.2	16498.7	21366.5
2750	26142.7	16578.5	21482.1
2760	26281.4	16658.5	21598.0
2770	26420.2	16738.5	21714.1
2780	26559.2	16818.5	21830.5
2790	26698.4	16898.6	21947.1
2800	26837.6	16978.7	22063.9
2810	26977.1	17058.9	22181.0
2820	27116.7	17139.2	22298.3
2830	27256.4	17219.5	22415.9
2840	27396.3	17299.9	22533.7
2850	27536.3	17380.3	22651.7
2860	27676.5	17460.8	22770.0
2870	27816.8	17541.3	22888.6
2880	27957.3	17621.9	23007.3
2890	28097.9	17702.6	23126.4
2900	28238.7	17783.3	23245.6
2910	28379.6	17864.0	23365.2
2920	28520.7	17944.9	23484.9
2930	28661.9	18025.7	23605.0
2940	28803.2	18106.7	23725.2
2950	28944.7	18187.7	23845.7
2960	29086.4	18268.7	23966.5
2970	29228.2	18349.8	24087.6
2980	29370.1	18430.9	24208.8
2990	29512.2	18512.2	24330.4
3000	29654.4	18593.5	24452.2
3010	29796.7	18674.8	24574.2
3020	29939.2	18756.2	24696.5
3030	30081.8	18837.7	24819.1
3040	30224.6	18919.2	24941.9
3050	30367.5	19000.8	25065.0
3060	30510.5	19082.4	25188.3
3070	30653.7	19164.1	25312.0
3080	30797.0	19245.8	25435.8
3090	30940.5	19327.6	25559.9
3100	31084.1	19409.5	25684.4
3110	31227.8	19491.4	25809.0
3120	31371.7	19573.4	25933.9
3130	31515.7	19655.5	26059.1
3140	31659.8	19737.5	26184.6
3150	31804.1	19819.7	26310.3
3160	31948.5	19901.9	26436.3
3170	32093.0	19984.2	26562.6
3180	32237.7	20066.5	26689.1
3190	32382.5	20148.9	26815.9
3200	32527.4	20231.4	26943.0
3210	32672.4	20313.9	27070.4
3220	32817.6	20396.5	27198.0
3230	32962.9	20479.1	27325.9
3240	33108.4	20561.8	27454.1
3250	33254.0	20644.5	27582.5
3260	33399.7	20727.3	27711.3
3270	33545.5	20810.2	27840.3
3280	33691.4	20893.1	27969.6
3290	33837.5	20976.1	28099.1
3300	33983.7	21059.2	28229.0
3310	34130.1	21142.3	28359.1
3320	34276.5	21225.5	28489.5
3330	34423.1	21308.7	28620.2
3340	34569.8	21391.9	28751.2
3350	34716.6	21475.3	28882.5
3360	34863.6	21558.7	29014.0
3370	35010.7	21642.2	29145.8
3380	35157.8	21725.8	29278.0
3390	35305.2	21809.4	29410.4
3400	35452.6	21893.0	29543.1
3410	35600.2	21976.7	29676.1
3420	35747.8	22060.5	29809.3
3430	35895.6	22144.3	29942.9
3440	36043.5	22228.2	30076.8
3450	36191.6	22312.2	30210.9
3460	36339.7	22396.2	30345.4
3470	36488.0	22480.3	30480.1
3480	36636.4	22564.4	30615.1
3490	36784.9	22648.6	30750.5
3500	36933.5	22732.9	30886.1
3510	37082.2	22817.2	31022.0
3520	37231.1	22901.6	31158.3
3530	37380.0	22986.1	31294.8
3540	37529.1	23070.6	31431.6
3550	37678.3	23155.2	31568.8
3560	37827.6	23239.8	31706.2
3570	37977.0	23324.5	31843.9
3580	38126.5	23409.3	31982.0
3590	38276.2	23494.1	32120.3
3600	38425.9	23579.0	32258.9
3610	38575.8	23664.0	32397.9
3620	38725.7	23749.0	32537.2
3630	38875.8	23834.0	32676.7
3640	39026.0	23919.2	32816.6
3650	39176.3	24004.4	32956.8
3660	39326.7	24089.7	33097.3
3670	39477.2	24174.9	33238.1
3680	39627.8	24260.4	33379.2
3690	39778.5	24345.8	33520.6
3700	39929.3	24431.3	33662.4
3710	40080.3	24516.9	33804.4
3720	40231.3	24602.6	33946.8
3730	40382.4	24688.3	34089.5
3740	40533.7	24774.1	34232.5
3750	40685.0	24859.9	34375.8
3760	40836.4	24945.8	34519.5
3770	40988.0	25031.7	34663.5
3780	41139.6	25117.8	34807.7
3790	41291.4	25203.9	34952.3
3800	41443.2	25290.0	35097.3
3810	41595.2	25376.2	35242.5
3820	41747.2	25462.5	35388.1
3830	41899.4	25548.9	35534.0
3840	42051.6	25635.3	35680.2
3850	42204.0	25721.8	35826.7
3860	42356.4	25808.3	35973.6
3870	42508.9	25894.9	36120.8
3880	42661.6	25981.6	36268.4
3890	42814.3	26068.3	36416.2
3900	42967.1	26155.1	36564.4
3910	43120.0	26241.9	36712.9
3920	43273.0	26328.9	36861.8
3930	43426.1	26415.9	37011.0
3940	43579.3	26502.9	37160.5
3950	43732.6	26590.1	37310.3
3960	43886.0	26677.3	37460.5
3970	44039.5	26764.5	37611.1
3980	44193.1	26851.9	37761.9
3990	44346.7	26939.3	37913.1
4000	44500.4	27026.7	38064.7
4010	44654.3	27114.2	38216.5
4020	44808.2	27201.8	38368.7
4030	44962.2	27289.4	38521.3
4040	45116.3	27377.2	38674.2
4050	45270.5	27464.9	38827.4
4060	45424.8	27552.8	38981.0
4070	45579.1	27640.7	39135.0
4080	45733.6	27728.7	39289.2
4090	45888.1	27816.8	39443.8
4100	46042.7	27904.9	39598.8
4110	46197.4	27993.0	39754.1
4120	46352.2	28081.3	39909.8
4130	46507.1	28169.6	40065.8
4140	46662.0	28258.0	40222.2
4150	46817.1	28346.4	40378.9
4160	46972.2	28434.9	40535.9
4170	47127.4	28523.5	40693.3
4180	47282.7	28612.2	40851.1
4190	47438.0	28700.9	41009.2
4200	47593.5	28789.7	41167.7
4210	47749.0	28878.5	41326.6
4220	47904.6	28967.5	41485.7
4230	48060.3	29056.4	41645.3
4240	48216.0	29145.5	41805.2
4250	48371.8	29234.6	41965.5
4260	48527.7	29323.8	42126.1
4270	48683.7	29413.1	42287.1
4280	48839.8	29502.4	42448.4
4290	48995.9	29591.8	42610.1
4300	49152.1	29681.3	42772.2
4310	49308.4	29770.8	42934.6
4320	49464.8	29860.4	43097.4
4330	49621.2	29950.0	43260.6
4340	49777.7	30039.8	43424.1
4350	49934.3	30129.6	43588.0
4360	50090.9	30219.5	43752.3
4370	50247.6	30309.4	43916.9
4380	50404.4	30399.4	44082.0
4390	50561.3	30489.5	44247.3
4400	50718.2	30579.6	44413.1
4410	50875.2	30669.8	44579.2
4420	51032.2	30760.1	44745.1
4430	51189.4	30850.5	44912.6
4440	51346.6	30940.9	45079.8
4450	51503.8	31031.4	45247.4
4460	51661.2	31122.0	45415.4
4470	51818.6	31212.6	45583.8
4480	51976.0	31303.3	45752.6
4490	52133.6	31394.1	45921.7
4500	52291.2	31484.9	46091.2
4510	52448.8	31575.8	46261.1
4520	52606.5	31666.8	46431.4
4530	52764.3	31757.8	46602.0
4540	52922.2	31849.0	46773.0
4550	53080.1	31940.2	46944.5
4560	53238.0	32031.4	47116.3
4570	53396.1	32122.7	47288.5
4580	53554.2	32214.1	47461.0
4590	53712.3	32305.6	47634.0
4600	53870.5	32397.2	47807.4
4610	54028.8	32488.8	47981.1
4620	54187.1	32580.5	48155.2
4630	54345.5	32672.2	48329.7
4640	54503.9	32764.0	48504.7
4650	54662.4	32855.9	48679.9
4660	54821.0	32947.9	48855.7
4670	54979.6	33039.9	49031.8
4680	55138.3	33132.0	49208.2
4690	55297.0	33224.2	49385.1
4700	55455.8	33316.5	49562.4
4710	55614.6	33408.8	49740.1
4720	55773.5	33501.2	49918.1
4730	55932.4	33593.6	50096.6
4740	56091.4	33686.2	50275.5
4750	56250.4	33778.8	50454.8
4760	56409.5	33871.5	50634.4
4770	56568.6	33964.2	50814.5
4780	56727.8	34057.1	50995.0
4790	56887.1	34149.9	51175.9
4800	57046.4	34242.9	51357.2
4810	57205.7	34335.9	51538.9
4820	57365.1	34429.1	51721.0
4830	57524.5	34522.3	51903.5
4840	57684.0	34615.5	52086.4
4850	57843.5	34708.8	52269.7
4860	58003.1	34802.2	52453.4
4870	58162.7	34895.7	52637.6
4880	58322.4	34989.3	52822.1
4890	58482.1	35082.9	53007.1
4900	58641.8	35176.6	53192.5
4910	58801.6	35270.3	53378.2
4920	58961.4	35364.2	53564.5
4930	59121.3	35458.1	53751.1
4940	59281.2	35552.1	53938.1
4950	59441.2	35646.1	54125.6
4960	59601.2	35740.3	54313.4
4970	59761.2	35834.5	54501.7
4980	59921.3	35928.8	54690.4
4990	60081.4	36023.1	54879.6
5000	60241.6	36117.5	55069.1

News of EQUIPMENT

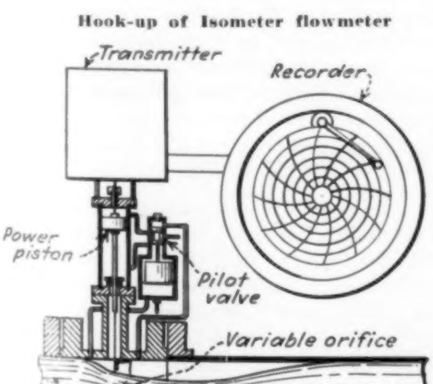
Novel Flowmeter

Whereas the usual orifice-type flowmeter measures the variable pressure drop across a fixed orifice in the line, the new Isometer, manufactured by the Elgin Softener Corp., Elgin, Ill., employs a constant pressure drop which is maintained by changing the size of orifice opening as flow through the orifice varies. It is claimed that the varying-orifice principle makes it possible to measure low rates of flow accurately down to as low as 2½ per cent of the meter capacity. It is also said that pulsating flow can be measured more accurately. Errors due to friction are claimed to be eliminated because the power of the orifice actuating mechanism is far in excess of that actually required to move the orifice gate.

The Isometer consists of two parts, the actuator and the meter unit. The former, which is located in the pipeline, consists of a flanged cylindrical section at the center of which is mounted a set of plates forming a variable orifice. The pressure differential across the orifice operates a system consisting of a pilot valve and power piston to maintain the constant differential desired, by adjusting the size of orifice.

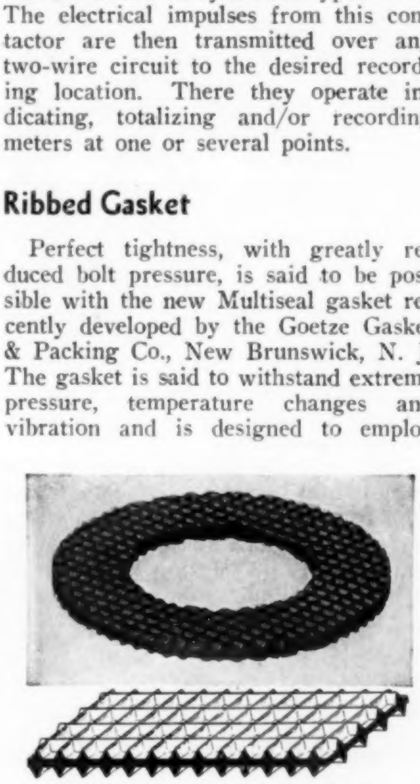
Under this arrangement, the opening of the orifice is a measure of the flow. The vertical movement of the orifice gate is used to adjust an electrical contact device driven by a clock-type motor. The electrical impulses from this contactor are then transmitted over any two-wire circuit to the desired recording location. There they operate indicating, totalizing and/or recording meters at one or several points.

Hook-up of Isometer flowmeter



Ribbed Gasket

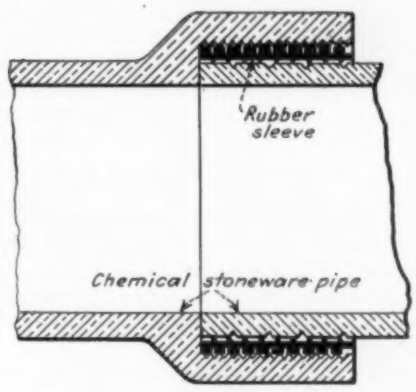
Perfect tightness, with greatly reduced bolt pressure, is said to be possible with the new Multiseal gasket recently developed by the Goetze Gasket & Packing Co., New Brunswick, N. J. The gasket is said to withstand extreme pressure, temperature changes and vibration and is designed to employ only 30 per cent as much contact surface as on a plain, flat, metal gasket. This is accomplished by providing the faces with crossed, ductile and resilient raised ribs. These gaskets are available in solid copper, steel, Armco iron, aluminum or lead, or as a metal shell with asbestos filler. Circular, elliptical and a variety of special shapes are obtainable.



Ribbed gasket and sectional view

Rubber Joint

For the jointing of chemical stoneware pipe, the U. S. Stoneware Co., Akron, Ohio, is providing the new Flexlock rubber joint which makes possible the use of lower cost bell and spigot chemicalware pipe for all purposes, including pressure lines. It is stated that this construction in the case of long lines reduces installed cost by as much as 50 per cent in some cases. Furthermore, a 4-in. chemical stoneware line using this joint has been tested to over 80 lb. per sq.in. pressure without joint leakage.



Cross-section of Flexlock rubber joint

This joint is formed using a rubber sleeve of cross-section as shown in the drawing. Smaller joints may be assembled by hand while larger joints are readily jacked together. The joint gives mechanical flexibility to the line, making possible an angularity as high as 15 deg. Furthermore, since only the exposed edge of the joint comes in contact with the material handled, such rubber-destroying chemicals as chlorine, sulphuric acid and nitric acid are handled satisfactorily.

This company has also announced that it is now prepared to supply triple-spiral packing rings, in addition to single- and double-spiral types, in both Cyclohelix and Hexahelix shapes, under the Fairlie patent.

Equipment Briefs

A priming chamber, with integral by-pass and relief valves, said to permit the handling of volatile liquids in the hottest summer weather, has recently been added by the Roots-Connersville Blower Corp., Connersville, Ind., to its standard Type T turbine pump. This pump was originally described in the July, 1933, issue of *Chem. & Met.* Through this improvement it is stated that even high-gravity gasoline can be unloaded from tank cars when the liquid temperature exceeds 100 deg. F. Pumps are built in sizes ranging from 20 to 350 g.p.m.

Robins Conveying Belt Co., 15 Park Row, New York City, has announced a new mechanically vibrated screen known as the Vibrex, which is actuated by a rotating shaft carrying adjustable, eccentric weights placed near the center of gravity of the screen. Easy stroke and slope adjustment are possible, and the screen is insulated by heavy springs from its support, so as to localize vibration. Widths of 3 and 4 ft. and lengths of 6½ and 8½ ft., single or double-deck, are

standard. 10-ft. single-deck screens are also available.

An industrial white light said to be restful on the eyes and to permit increased efficiency in high-bay lighting has been developed by the General Electric Vapor Lamp Co., Hoboken, N. J. The new lamp is not actually white. It combines light blue and yellow green which, however, produce a whiter sensation to the observer. The lamp produces an intensity of 14,000 lumens at a current consumption of approximately 1 watt per 35 lumens.

Two rubber-like cements which are oil-proof, unaffected by most ordinary solvents, and highly resistant to moisture, sunlight, oxidation and ozone, have been announced by the Thiokol Corp., Yardville, N. J. Cement C-1 is a thick dough especially prepared for spreading operations in rubber manufacturing plants for coating fabrics. Cement C-2 is a cement of lower viscosity and less pigment loading. It contains 72 per cent solvent by weight. These cements are recommended for all sorts of coating, impregnation, binding and sealing operations.

Midwest Piping & Supply Co., 1450 South Second St., St. Louis, Mo., has announced a new line of welding ells of carbon steel with a stainless steel lining. These ells are said to provide the protection of 18-8 stainless steel at prices considerably lower than welding ells made entirely from stainless steel. Such fittings are also available with the stainless covering outside rather than inside the ell.

For drying operations in which contamination by iron oxide during the drying must be avoided, the Philadelphia Drying Machinery Co., 3351 Stokley St., Philadelphia, Pa., has developed a corrosion-proof dryer of aluminum or other alloys, said to give longer satisfactory service than dryers rust-proofed by other methods. This dryer employs aluminum heating coils, structural aluminum frame and aluminum sheets for all internal partitions, as well as for inside sheets of all insulating panels. All surfaces in contact with the recirculated, heated and humid air are of aluminum or aluminum alloy construction.

Air pressure is used in the new 2-qt. vaporizing-liquid fire extinguisher made by the Pyrene Mfg. Co., Newark, N. J., in discharging the liquid. Prior to use, the compressed air chamber is supplied with air from any line having a pressure of 100 lb. or more. Only occasional checking of the air pressure is necessary. The nozzle is designed to give a fan-shaped spray when partially open, and a solid stream that can be thrown 30 ft. or more, when fully open.

Two new recording draft gages, employing slack leather diaphragms rather than liquid columns, and suitable for ranges between 0.1 and 100 in. of water, have been announced by the Hays Corp., Michigan City, Ind. The series OT instruments are described as "sensitive" and the series OH instruments as "super-sensitive." Both are equipped with 10-in. charts. The former is available in one- and two-pen models. The latter, for applications requiring greatest accuracy, may be read as closely as 0.0005 in. of water.

Pneumatic Wrench

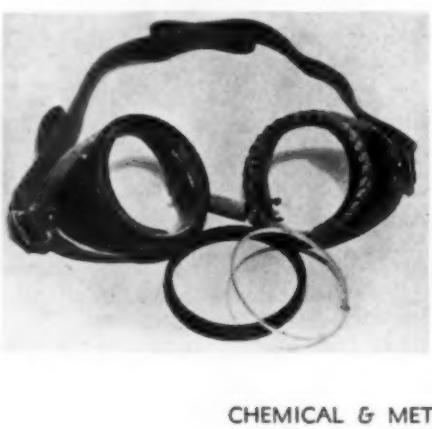
Removal or replacement of nuts in heat exchangers, pressure vessels, kettle heads and other equipment is readily accomplished according to the Ingersoll-Rand Co., Phillipsburg, N. J., with the new Ingersoll-Rand Pott impact wrench. The principle employed in this wrench is said to be entirely new in the pneumatic tool field. The wrench is operated by a multi-vane airmotor. Between the motor and chuck is interposed a device consisting of three parts, a rubber accumulator, a hammer and an anvil. In operation, the torque of the motor is applied to the accumulator which, in twisting becomes shortened, lifting the hammer from engagement with the anvil. The hammer is then released and spun forward to the next engagement, thus delivering a powerful blow to the anvil, on the end of which the chuck is attached.

The torsional impacts occur at the rate of 1,200-1,400 blows per minute and are said to be capable of starting frozen nuts which otherwise could be removed only by splitting with a chisel or burning with a torch. One man can operate the wrench with ease and without danger, according to the manufacturer.

Chemical Goggle

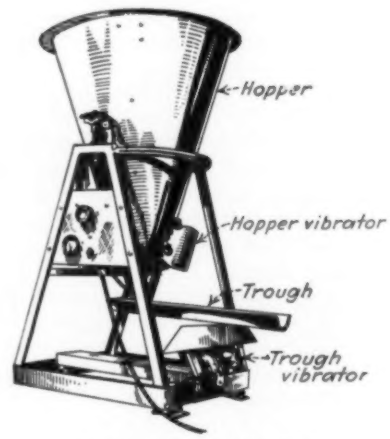
Effective ventilation, combined with complete protection from splashes of corrosive liquids and impact of flying particles, is offered in a new goggle recently announced by the American Optical Co., Southbridge, Mass. This new goggle, known as AO Duralite-50 Chemical Goggle, is constructed with molded eye-cups, slotted under the lens ring, so as to promote air circulation. The perforated side shields are backed up with a solid baffle plate to isolate the eyes from splashes, at the same time permitting circulation of air over the lenses. The lenses are case-hardened and are said to provide maximum lens protection from impact. The bridge is of the rubber-covered, ball-chain type and is readily adjustable. The goggles are said to combine maximum wearing comfort with complete freedom from fogging.

New ventilated chemical goggle



Vibratory Feeder

Complete absence of wearing parts is attained in a new vibratory feeder for dry chemicals developed by the Syntron Co., Pittsburgh, Pa. The feeder consists of a vibrated hopper, a vibrating trough feeder, a rheostat controlling the volume flow of the feeder and a control box for the two vibrating elements. The feeder capacity ranges from 2 oz. to 2,000 lb. per hour. Flow is continuous and steady and the volume is under instant control. As the feeder may be instantly stopped, it is said to be adaptable to use in automatic packaging machinery as well as in such other applications as feeding water-treating chemicals and proportioning a number of materials. Power consumption is stated to be less than 200 watts.



Feeder for dry chemicals

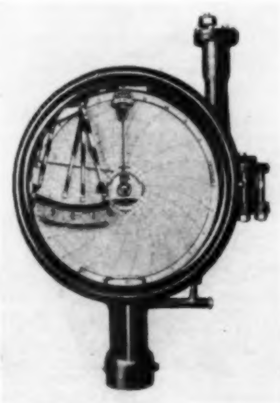
Self-Priming Pump

Dependability is said to be an outstanding characteristic of a new close-coupled, self-priming pump, recently announced by the Worthington Pump & Machinery Corp., Harrison, N. J. The pump is primed automatically, without the use of floats, hand-operated valves or recirculation, by a Worthington-built Hytor which is placed on the same shaft with the pump and motor. When the pump is primed, a pressure-

operated cutout automatically unloads the Hytor. The pump is available for single or polyphase, 50 or 60 cycle a.c. and for d.c. operation. Sizes range from 50 to 400 g.p.m. at heads from 25 to 150 ft.

Universal Meter

The Foxboro Co., Foxboro, Mass., has developed a universal flowmeter designed to measure any fluid under any industrial conditions. The new meter has a flow rangeability of 10-to-1, a uniformly graduated chart and, if necessary, a temperature and/or pressure pen. A new mechanical integrator is provided, totalizing on a counter. If desired, a transparent indicating scale may be provided.



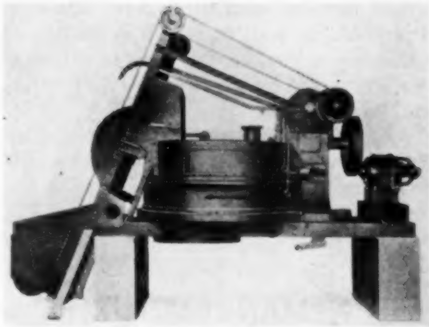
New universal meter for all fluids

Feed Pump

For the pumping of exact quantities of water-treating chemicals into water supplies, at a rate dependent upon water flow, the Dearborn Chemical Co., 310 South Michigan Ave., Chicago, Ill., has introduced a new chemical pump of the plunger type with stroke adjustment variable from 0 to 3 in. Plungers are made of special alloys and all working parts of nickel semi-steel. The construction is described as rugged and the action as smooth and steady, without lost motion, at all operating speeds. Construction features include a guided plunger and centered ball bearings. Pressure lubrication is employed.

Batch Mixer

C. O. Bartlett & Snow Co., Cleveland, Ohio, announces that it is now building the Lancaster mixer (originally described in *Chem. & Met.*, p. 266, May, 1933). The equipment is being offered in a series of seven standard sizes ranging from 2/3 to 36 cu.ft. capacity, in both open and closed models, with or without loading hoppers. The accompanying illustration shows one of the larger mixers, complete with loading equipment.



Lancaster mixer and loading hopper

From the earlier description it will be recalled that this machine consists of a revolving pan which carries the ingredients into the mixing area where one or more assemblies of plows, or plows and mullers, whirling in counter directions, produce a thorough and homogeneous mix in extremely short time, according to the manufacturer. The machine is adapted to a wide range of mixing problems with such products as glass, refractories, putty, enamels, and various pharmaceuticals, handling mixes of dry or plastic materials.

Turbine-Type Mixer

Patterson Foundry & Machine Co., East Liverpool, Ohio, has announced that its Type E mixer is now being regularly supplied with a Style TD stirrer consisting of a turbine with diffusing ring. This type stirrer is said to be particularly effective where solids must be kept in suspension in liquids or where liquids are to be mixed in solids or with other liquids or with air or gases, for blending, dissolving, emulsifying or heat transfer. This type of mixer is available either for belt drive or with this company's Unipower agitator drive, as illustrated. Mixers may be supplied with a single turbine at the bottom or with an additional turbine or turbines placed at intervals on the shaft, with or without diaphragms or draught tubes.

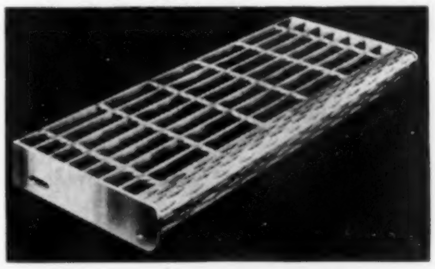
Cutaway view of improved mixer

Corrosion-Resisting Paint

"Acidseal" is the name of the new line of corrosion-resisting paints recently introduced by the B. F. Goodrich Co., Akron, Ohio. The binder used is a rubber isomer which is hard and flexible and which gives the paint practically the same resistance as crude rubber. Acids and alkalies are said to have no effect with the exception of those of an oxidizing character such as nitric acid or sodium hypochlorite. The paints are recommended wherever corrosive conditions exist but not for exposure to direct sunlight. They are handled much like lacquers by brushing, spraying or dipping. They are said to adhere well to all surfaces and are available in a wide range of practical colors.

Non-Slip Tread

In the accompanying view is shown the new Electroforged stair tread manufactured by the Blaw-Knox Co., Pittsburgh, Pa. The nosing is made from rolled, diamond-checkered plate and the tread assembled by electroforging without cutting, slotting or punching the bars or removing metal in any way. The twisted cross-bars are said to afford maximum safety under wet, greasy or icy conditions.



Improved metal stair tread

Duplex Vibrating Screen

A novel, easily removable lock ring, making possible the ready use of throwaway cheesecloth disks, in place of wire cloth sieves, is a feature of the new Duplex screen for solids and liquids recently developed by the Paterson Engineering Co., 420 Sansom St., Philadelphia, Pa. The distributor for the screen is Arthur T. Ward, 50 Church St., New York, N. Y.

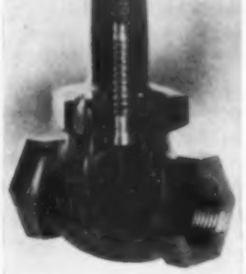
Another interesting new feature of this screen is an extra "Duplex" basket of smaller size which fits inside the main

basket, making possible two screenings at one time. The screen makes possible control of vibration which is quickly regulated to suit the mesh of sieve used and the product being screened. The screen weighs 75 lb. and is equipped with a $\frac{1}{3}$ hp. explosion-proof, dust-proof motor.

New duplex vibrating screen for wet and dry products

Renewable Valves

A new line of renewable bronze angle and globe valves has recently been put on the market by the Fairbanks Co., 393 Lafayette St., New York City. A radial seat between body and bonnet is said to ensure a tight joint and perfect alignment. The disk ring, of long fiber asbestos compounded with vulcanizing elements, is suitable for steam, hot and cold water. The stem is of high-tensile rolled bronze, with at least five threads at all times in contact with the bonnet. All parts are interchangeable.



Cross-section of improved globe valve

Viscosity Indicator

For use on fuel oil heaters and in the manufacture of varnishes, paints, chemicals and other materials, the Sterling Engine Co., 1270 Niagara St., Buffalo, N. Y., has developed a viscosity indicator which may optionally be equipped with an electric switch for controlling. Material, the viscosity of which is to be measured, flows through a pipe in the wall of which is an orifice admitting a part of the flow to a chamber controlled by a pressure-relief valve. In this chamber is an outlet orifice through which the pressure-controlled liquid flows into a smaller chamber discharging through a friction tube. The pressure in this second chamber is indicated on a dial in terms of viscosity. If control is desired, this pressure serves to operate a pressure switch. As it leaves the friction tube, the liquid returns to the reservoir from which the original flow was supplied. The instrument is calibrated in Saybolt seconds or other units and is said to be capable of control, accurate to 5 Saybolt seconds.

MANUFACTURERS' LATEST PUBLICATIONS

Air Conditioning. The Trane Co., La Crosse, Wis.—4 pages describing small comfort coolers for water or direct expansion refrigerants.

Alloys. Burgess-Parr Co., Moline, Ill.—4-page leaflet describing some recent applications of Illium-G.

Alloys. International Nickel Co., 67 Wall St., New York City—Bulletin C-1—8 pages on properties of Monel metal with description of the uses of this material in the manufacture of soap; Bulletin H-1, 4 pages on the application of Monel metal in pumps.

Apparatus. U. S. Stoneware Co., 50 Church St., New York City—Leaflet describing stoneware Kjeldahl equipment.

Asbestos Products. General Asbestos & Rubber Division, Raybestos-Manhattan, Inc., North Charleston, S. C.—24 pages covering a variety of asbestos textiles including fabrics, yarns, cords, rope, fibers and tape; and the products made from these materials, such as bags, diaphragms, filter cloths, etc.

Chemicals. Dow Chemical Co., Midland, Mich.—16-page book covering, largely with illustrations, several phases of this company's activities in chemical and metallurgical fields.

Compressors. Worthington Pump & Machinery Corp., Harrison, N. J.—L-620-B8—6 pages on vertical, angle two-stage air compressors; L-621-B6, 4 pages on vertical, single-stage air compressors.

Crushing and Grinding. Hardinge Co., York, Pa.—Ah-323—First official publication of this company on the Hardinge-Hadsel mill, describing a specific installation, giving data on various mill sizes, and giving crushing and grinding costs in comparison with conventional equipment.

Electrical Equipment. Allis-Chalmers Mfg. Co., Milwaukee, Wis.—Bulletin 1169—12 pages describing construction and applications of this company's mercury-arc power rectifiers.

Electrical Equipment. Century Electric Co., St. Louis, Mo.—8 pages briefly describing constructional features of $\frac{1}{4}$- to 600-hp. polyphase motors made by this company.

Electrical Equipment. General Electric Co., Schenectady, N. Y.—Publications as follows: GEA-1839, 80 pages on cable accessories, describing methods of jointing insulated cable; GEA-1972, oil-blast circuit breaker for 600-1,200 amp.; GEA-2123, outdoor fuse disconnecting switch; GEA-2127, knife switches for 500 and 600 volts.

Electrical Equipment. Roller-Smith Co., 233 Broadway, New York City—Catalog 48—Describes a variety of a.c. and d.c. meters for electrical measurements, including pyrometers; Catalog 8, Supplement 1, deals with air and oil breakers and "self-standing" steel panels.

Equipment. Cameron Machine Co., 61 Poplar St., Brooklyn, N. Y.—56 pages covering a wide range of slitting and roll-winding machinery for paper, together with accessories made by this company.

Equipment. J. P. Devine Mfg. Co., Mt. Vernon, Ill.—Condensed General Catalog No. 105-B—12 pages briefly describing the complete line of process equipment made by this company; four additional pages of engineering charts and tables.

Equipment. W. S. Rockwell Co., 50 Church St., New York City—Catalog [illegible]61—4 pages on air-tight blast gates made by this company.

Forgings. Kropp Forge Co., 5301 West Roosevelt Rd., Chicago, Ill.—4-page leaflet showing typical forgings produced by this company.

Heat Exchange. York Ice Machinery Corp., York, Pa.—Bulletins 35,238, 39, 40—2-page leaflets covering respectively vertical shell-and-tube condensers, single-pass type; horizontal shell-and-tube condensers, multi-pass type; and horizontal shell-and-tube brine coolers.

Instruments. Chemical & Research Corp., 9308 Santa Monica Blvd., Beverly Hills, Calif.—Leaflet describing the Allison Electrometer, an instrument for measuring electromotive force for determining pH values, for potentiometric titrations, for conductivity and resistance measurements and other electrometric investigations.

Instruments. Leeds & Northrup Co., 4900 Stenton Ave., Philadelphia, Pa.—Bulletin 4001—24 pages on the use of electrical thermometers in connection with air conditioning systems.

Materials Handling. Link-Belt Co., 2045 West Hunting Park Ave., Philadelphia, Pa.—Catalog 1542—16 pages on collectors for removing sludge and scum from rectangular tanks in sewage and water treatment plants.

Materials Handling. The Re-Bo Co., Watertown, N. Y.—Leaflet describing Re-Bo removable bodies for hand trucks and showing their application in the reduction of handling costs.

Nozzles. Binks Mfg. Co., 3114 Carroll Ave., Chicago, Ill.—Bulletin 50—Covers a complete line of spray nozzles for water cooling, air conditioning, industrial and other applications.

Power Transmission. Graton & Knight Co., Worcester, Mass.—44-page book discussing in detail the economics of the two generally used power transmission systems: individual motor and modern group drive.

Pumps. Allis-Chalmers Manufacturing Co., Milwaukee, Wis.—Leaflet 2199—4 pages describing motorized, close-coupled centrifugal pumps.

Pumps. Gardner-Denver Co., Quincy, Ill.—4-page leaflet describing a new line of horizontal, single-stage, double-suction centrifugal pumps.

Pumps. Lawrence Machine & Pump Corp., 371 Market St., Lawrence, Mass.—Bulletin 201—Describes double-suction, horizontally split centrifugal pumps.

Pumps. Westco Pump Corp., Davenport, Ia.—Bulletin 679—4 pages describing new removable liners for this company's turbine pumps.

Pumps. Worthington Pump & Machinery Corp., Harrison, N. J.—W-102-B1—6 pages on turret-type, horizontal, duplex piston pumps; W-321-B2A, 6 pages on close-coupled, motorized centrifugal pumps.

Refractories. Harbison-Walker Refractories Co., Farmers Bank Bldg., Pittsburgh, Pa.—Three folders describing high-temperature bonding mortars, with list of applications for each. Mortars include Thermolith, with a chrome-ore base; Firebond, with a silica base; and Harwaco Bond, with a diaspore base.

Refractories. Ironton Fire Brick Co., Ironton, Ohio—Information Circular No. 3—Three pages on Ironton Bond, a high-temperature cement, giving information on properties, use and applications.

Regulators. American Meter Co., Reliance Regulator Corp. Division, 60 East 42d St., New York City—Bulletins 32 and 34—Describing the new Reliance Type P high-pressure gas regulator with cross-section photographs showing stream-line flow characteristics, said to increase capacity, improve uniformity of regulation and reduce upkeep.

Stills. Barnstead Still & Sterilizer Co., 2 Lanesville Terrace, Forest Hills, Boston, Mass.—6 pages describing solvent recovery stills and Soxhlet extractors made by this company.

Chemical Engineering NEWS

Chemical Engineers Plan British Trip for 1936

PRELIMINARY plans recently announced for an International Chemical Engineering Congress to be held in London, England, June 22-27, 1936, have now been followed by an invitation for a joint meeting between the British Institution of Chemical Engineers and the American Institute of Chemical Engineers. The invitation tendered by Dr. Herbert Levenstein, president of the Institution to Dr. Albert E. Marshall, president of the A. I. Ch. E., was accepted by Council of the latter organization and officially approved by the membership at its business meeting in Wilmington, Del., May 14. This will be the third in a series of joint sessions between these two groups. The first was in 1925 when 60 members and guests of the American Institute met in England, July 12-30. A return visit was made in 1928 when a party of 120 British members and guests joined in a tour of the United States and Canada, August 19-30.

Originally planned for 1930 but postponed because of economic conditions, the meeting next year promises some unusual features of international interest. As pointed out by President Marshall, in his article last month (see *Chem. & Met.*, May, 1935, p. 244-5), the Chemical Engineering Congress is to be held in connection with the World Power Conference, but is to have a distinctly autonomous program. Subjects to be featured include chemical engineering projects, plant construction, fuel and heat, development trends and general problems of administration and organization.

The joint meeting of the two societies is scheduled to begin on June 27 at the conclusion of the Congress and will probably extend to about ten days during which visits will be made to industrial and historic points of interest in the British Isles. Preliminary and very tentative estimates of the approximate cost of the entire trip place the minimum around $550 per person.

Other business discussed at the Wilmington session of the American Institute of Chemical Engineers included a report by F. C. Zeisberg, chairman of the publications committee on the proposed change in the Institute's publication policy. The experimental plan of issuing the Transactions in the form of a paper-bound quarterly has met with the following response: A questionnaire included with the January quarterly was returned by only 140 members, 73 of which favored the quarterly plan while 27 preferred the present annual cloth-bound volume. Mr. Zeisberg urged a more representative response from the membership.

The chairman also pointed out his committee's recommendation that the Institute should establish an award, to be known as the William H. Walker medal, the purpose of which is to stimulate interest and improve the quality and presentation of papers to appear in the Transactions. This proposal, with regulations governing the award, will again be submitted to Council before final authorization.

Sheppard T. Powell, consulting engineer of Baltimore, chairman of the joint committee (with A.S.C.E.) on pollution of streams described the cooperative work with the National Resources Board. Major industries contributing to stream pollution and focal points of pollution, were charted in a report which also brought out the approximate cost of purification. Mr. Powell recommended that the committee and the Institute should guard against legislation that would place undue burden on process industries during the consideration of this problem.

The next meeting of the Institute is to be held at Columbus, Ohio, November 13, 14 and 15. Professor J. R. Withrow of Ohio State University is to serve as general chairman.

Activated Carbon Patents Held Infringed

IN a decision rendered by the United States District Court for the District of Connecticut on May 13, the Chaney patents Nos. 1,497,543 and 1,497,544, covering activated vapor adsorbent carbon, were held valid and infringed.

The suit was brought by National Carbon Co., Inc., unit of Union Carbide and Carbon Corp. against Richards & Co., Inc., and The Zapon Co., of Stamford, Conn., because the two latter companies were using for solvent recovery activated coconut carbon which had been made by The Barnebey-Cheney Engineering Co., of Columbus, Ohio.

District Judge Hincks held that this constituted infringement of the plaintiff's patents, the claims of which he found valid. He rendered judgment in favor of the plaintiff for $24,410.65 on account of the infringement.

The Chaney patents were based on the wartime discoveries of Dr. N. K. Chaney and his associates in the National Carbon Co., Inc.,—discoveries that assured an ample supply of highly efficient gas-mask carbon at a time when the need was most urgent. After the war, it was found that this highly activated carbon was equally efficient for a variety of peacetime uses. In 1919, the National Carbon Company, Inc., began the manufacture of activated carbons by the Chaney process for industrial use.

American Potash Institute Formed in Washington

AMERICAN producers and importers of potash salts announce the organization of the American Potash Institute, Incorporated, which will be established in Washington, D. C., at an early date. The Institute has been organized to carry on scientific and agricultural investigations to promote the efficient and profitable use of potash in crop production.

It will be its policy to cooperate, as opportunity affords, with State and Federal institutions in carrying on research and experimental work in the United States, Canada and Cuba and with the agricultural work sponsored by the National Fertilizer Association and other scientific and trade organizations.

Dr. J. W. Turrentine, for years in charge of potash researches of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, has been appointed president. Dr. Turrentine has long been well known in America and Europe for his numerous researches, writings, and addresses on potash and other fertilizer subjects and his activities in connection with the development of the American potash industry. He has been connected with the U. S. Department of Agriculture since 1911, when the initial potash survey of the United States was inaugurated.

G. J. Callister, director of the Agricultural and Scientific Bureau, N. V. Potash Export My., Inc., and for 24 years connected with the educational work of the potash industry, will be vice-president and secretary. Both Messrs. Turrentine and Callister will sever their connections with their respective organizations when the Institute is established.

Exhibit of Apparatus at A.S.T.M. Detroit Meeting

IN addition to interesting displays by leading companies in the industry, the Exhibit of Testing Apparatus and Related Equipment which will be in progress during the week of the A.S.T.M. thirty-eighth annual meeting, June 24-28, at the Book-Cadillac, Detroit, will feature special instruments and apparatus as developed by A.S.T.M. committees and various research laboratories.

In the booths of the companies producing and distributing instruments, laboratory supplies, etc., there will be items of interest to many engineering materials fields, including ferrous and non-ferrous metals, ceramic, concrete and masonry materials, petroleum products, rubber products, paving materials, and others. Latest developments in research and testing apparatus will be shown by various companies.

Displays by society committees and research laboratories of special apparatus and equipment they have developed will form an interesting section of the Exhibit. A.S.T.M. Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys will have an extensive display showing many corroded specimens which have been collected from the various test racks throughout the country. The display will cover the committee's work in atmospheric, galvanic and electrolytic and liquid corrosion.

Committee B-6 on Die Cast Metals and Alloys will illustrate in its booth important phases of its work. There will be a number of samples of test specimens from various alloys, an extensive display of corrosion specimens which the committee has had under test for many years with records of corrosion progress at the various exposure points and an extensive series of sample die castings of various alloys.

Dow and Cleveland-Cliffs Form New Company

THE Dow Chemical Co., Midland, Mich., and the Cleveland-Cliffs Iron Co., Cleveland, announce that they have joined in organizing the Cliffs-Dow Chemical Co. The new company was incorporated at Lansing with an authorized capital of 25,000 shares of "A" preferred, 10,000 shares of "B" preferred, and 25,000 shares of common stock. The amount of capital issued at this time was not stated, but it is understood that arrangements have been made to dispose of shares to provide money for further expansion and development. The Cleveland-Cliffs Iron Co. has owned and operated a chemical plant at Marquette, Mich. for thirty years.

The scope of the new company will be to manufacture chemicals derived from wood, a field in which both companies have been experimenting and carrying on research work.

A. I. Ch. E. Sponsors Student Meeting in Philadelphia

ABOUT 150 members of the student chapters of the American Institute of Chemical Engineers met at Drexel Institute in Philadelphia, May 17 and 18 for a series of plant visits and technical sessions addressed by members of the Institute. Dean Leon D. Stratton of Drexel was chairman, assisted by Professor A. McLaren White of North Carolina who is chairman of the A. I. Ch. E. committee on student chapters. Speakers included Dr. Parke R. Kolbe, president of Drexel Institute, F. J. LeMaistre, executive secretary, Professor James R. Withrow of Ohio State, Chaplin Tyler, manager of sales development, Ammonia Department, duPont Company, Crosby Field, president, Flak-Ice Corporation, Thomas B. Drew of duPont Experimental Station, Philip L. Davison of Carrier Engineering Co., Louis J. Trostel, chief chemist, General Refractories Co., J. M. de Bell, chemical engineer of the Hercules Powder Co. and S. D. Kirkpatrick, editor of *Chem. & Met.*

Plant visits included trips to John T. Lewis, Inc., Pennsylvania Sugar Co., Atlantic Refining Co., Grasselli Chemical Co. A visit to the Fels Planetarium of Franklin Institute and a dance at the Drexel Women's Dormitory provided an interesting social program.

Krebs Opens New Titanium Pigment Plant

THE Krebs Pigment and Color Corp. has announced that three new pigments will be manufactured at their new plant in Edge Moor, Del. Edge Moor is located on the Delaware River about three miles north of Wilmington. The main office of the company was recently transferred from Newark, N. J., to 1007 Market St., Wilmington.

These new pigments will be called TI-CAL LO, TI-CAL HO and TI-BAR and are extended titanium pigments, having calcium sulphate and barium sulphate bases as indicated by their respective names.

The new plant, modern in every detail, comprises twenty buildings. The company is now operating plants in Newark, N. J., where a complete line of dry colors and lithopone are made; in Baltimore where titanium dioxide is manufactured and in Newport, Del., where lithopone is also produced.

Large Increase in Pyrites Production in 1934

PRODUCTION of pyrites in 1934 amounted to 432,524 long tons, valued at $1,216,363, compared with 284,311 tons, valued at $769,942 in 1933, an increase of 52 per cent in quantity and 58 per cent in value. Production in 1932 totaled 189,703 tons, valued at $498,-570 according to a report from the U. S. Bureau of Mines.

Tennessee was the largest producing State in 1934; others were California, Colorado, Missouri, Montana, New York, Virginia, and Wisconsin. New York increased its output of pyrites from 19,824 long tons in 1933 to 31,674 tons in 1934, a gain of 11,850 tons or 60 per cent. Production in 1932 amounted to 16,871 tons.

Production in Missouri decreased from 18,355 long tons in 1933, to 14,557 tons in 1934, a decline of 21 per cent. In 1932, 3,958 tons was produced in this State. Colorado shipped 5,303 long tons of pyrites in 1934 from the mill-tailings dump of the Colorado Zinc Lead Mill in Lake County. Shipments from this property totaled 4,059 tons in 1933, and 1,496 tons in 1932.

In 1934 the quantity of pyrites sold or consumed by producing companies amounted to 431,340 tons, a gain of 53 per cent, compared with 282,583 tons in 1933. The amount sold or consumed in 1932 was 188,872 tons. The pyrites produced in 1934 contained approximately 167,645 long tons of sulphur; in 1933 the output contained 107,778 tons, and in 1932, 66,432 tons.

Chemical Show Will Feature Advances in Equipment

IN addition to its display of raw materials and finished products the Fifteenth Exposition of Chemical Industries which will be held at Grand Central Palace, New York, Dec. 2-7, promises to offer an exhibit of equipment in terms of heavy plant machinery and the innumerable accessory machine units which serve industrial plants and represent the handling of mass production operations after they have been worked out in the laboratory and semi-work's production scale. Quite naturally this trend will be responsive to the fact that the American market, after years of depression, has a stored up demand for capital goods and for plant equipment generally, to replace units which the mere factor of obsolescence should have replaced sooner. As a background for building and machine maintenance the chemical processes to be handled must certainly be advanced by the unprecedented backlog of research facts which are available.

NEWS FROM WASHINGTON

By PAUL WOOTON

Washington Correspondent of Chem. & Met.

BUSINESS gets its chance. If by next April it can show a good record, demonstrate its good faith in asking just a few weeks ago for this chance to show that, without compulsion, it can maintain high standards in wages, working conditions and trade practices, the Administration will not be able to revive government control.

Public opinion is not yet sufficiently strong to justify the President in proposing now any means that might be construed as circumventing the Supreme Court's decision in the Schechter case or a constitutional amendment for centralized government. The President won't be able to do this ten months from now nor go to the country in next year's Presidential campaign on a platform to destroy states' rights unless business fails to maintain order in its own house and permits the demise of NRA to demoralize conditions.

Obviously, the President doesn't expect that business operating on its own can show as fine a record of good behavior as business under NRA. He is prolonging that organization for the purpose of painting the contrast by reporting on conditions that prevail after government discipline is removed. The President minimizes the effectiveness, in maintaining code standards throughout all industry, of the stipulation that such standards must be complied with in all contracts for supplying the government with goods and services. In deprecating this means of preserving "the larger objectives of NRA," the President reveals that he doesn't believe business voluntarily can keep chiseling backsliders in line and march on to recovery.

Actually the effect of the Administration's policy in dealing only with those firms which maintain code standards reaches back into business of every kind everywhere. It covers business done on loans from the government as well as purchases made by the government and contracts for construction and other services.

The President's figure of one per cent of total industrial production as representing the dollar volume of business which the government controls is a very low estimate, but if all business holds to the requirements imposed with respect to government contracts, it need be of no concern that henceforth, such government business goes only to the low bidder who maintains these standards. Incidentally the chiseler won't have a chance to wangle government orders as compliance with wage and hour standards will be written into law as a condition of all contracts and NRA will be constantly on the lookout for transgressions.

A real obstacle that the Administration has thrown in the way of business in demonstrating that it needs no NIRA or other statutory injunctions to maintain a high rating of efficiency and morality is the President's endorsement of the Wagner labor relations bill. By thus arming labor, enactment of the new labor law will harass business in this very critical period by subjecting it to employee dictation.

But even this should not deter industry from demonstrating conclusively that, neither in state nor interstate business, is there any necessity or any reason for further control over its operations by the government.

There is no blinking the fact that by next April or before, if business fails to come through with a vindication of its declaration of independence, that the President will have ready a new set of harness and that he will have the people behind him for a new and much more comprehensive scheme of political regulation of business.

An agreement to cooperate with the Public Health Service in warning users of benzol against its hazardous characteristics has been entered into by 37 companies producing the product.

This is the fourth chemical that like agreements have been entered into for by their producers. The other products are carbon tetrachloride and similar volatile chlorinated liquid hydrocarbons, carbon bisulphide, and aniline oil.

The benzol agreement is effective June 27, 1935.

The Copeland food and drug bill (S. 5) has passed the Senate after it had been revived through a compromise with its opponents and despite somewhat dreary prospects; now it seems destined to pass the House, particularly if the present session lasts for some time.

In the House, the bill is before the Interstate Commerce committee which has previous legislation that will take it quite a while to dispose of; but it is expected that administration pressure will be brought to bear to get it out and enacted. Opponents of the measure have been mollified to a considerable degree by the amendments agreed to in the Senate and are now reported to be pushing for passage of the bill for fear that they may be confronted with a more stringent measure if it goes over to next session.

Drawn together by common problems producers of domestic potash are cooperating as never before. In an effort to prevent further demoralization of the market no additional leases for the development of potash on the public lands are being issued by the Interior Department. Closer relationships among domestic producers had its start April 8, when interests in the Carlsbad region of New Mexico met at a dinner in honor of George S. Rice, chief mining engineer of the U. S. Bureau of Mines. This dinner was arranged by H. I. Smith, of the Geological Survey, who is chief of the division of that bureau which deals with mineral leasing.

Industrial loans totaling $1,382,700 had been made up to April 1 by the Reconstruction Finance Corp. to the chemical industry. These loans are made primarily to furnish working capital, but when found essential a portion of the loan may be used for the purchase of equipment, for the payment of taxes, or for the purpose of reducing the face of mortgages.

A limitation of TVA's activities in weed killing chemicals to experiments only is favored by Chairman McSwain of the House Military Affairs Committee, he revealed during the course of hearings before that body on the Norris amendments to the Authority's law.

In the Senate Norris had incorporated in the amendments a provision authorizing TVA "to experiment in the production of chemicals for the killing of weeds." Representative McSwain said he was willing to have the words "the production of," which would in effect limit the Authority's activity to experiments in application of such chemicals.

This announcement by the committee chairman came during a session in which Bethune G. Klugh, vice-president, Swann Chemical Co., declared that there was no public need or justification for TVA entering the chemical business. He told the committee that there is no evidence so far that heavy expenditures by the Authority have resulted in progress in chemical art.

Mr. Klugh added that the enormous installed capacity of phosphoric acid by TVA places a cloud of uncertainty over every branch of the chemical industry producing phosphoric acid or its derivatives.

If TVA chemical work is only of an experimental nature, why should it have a capacity equivalent to 50,000 tons a year of phosphoric acid or 300,000 tons of standard commercial fertilizer, he asked.

Chemical Manufacturers to Continue All-Industry Program

CHEMICAL manufacturers, assembled at Skytop, Pa., June 6 for the 63rd annual meeting of the Manufacturing Chemists' Association, went on record unanimously with agreement "that the chemical industry should continue to maintain the reputation it has always had for high wages and good working conditions" and strongly recommended "that all members of the industry should make it a particular point to see that this reputation does not suffer." The Chemical Alliance, Inc., war-time agency revived to carry on cooperative activities under NIRA, is not to be dissolved but will remain in existence to deal with problems that require unified, cooperative action on the part of the whole industry.

William B. Bell, president of both the Manufacturing Chemists' Association and the Chemical Alliance, Inc., again demonstrated his remarkable grasp of the economic problems of the industry and nation in an address that was easily the feature of the convention. His calm and dispassionate analysis of recent developments ended on the high note of optimism in ultimate and sound business recovery, once governmental experimentation and fallacious policies are abandoned. The recent Supreme Court decisions are most encouraging in restoring confidence. In Mr. Bell's opinion at least half of the New Deal is now jettisoned as a result of the Court's work. When AAA, the securities and stock exchange acts, and the banking bill are re-examined in the new light of constitutional authority, they will become less menacing and harmful to industry.

In a penetrating and devastating fashion, Mr. Bell indicted one after another of the popular nostrums and panaceas of the political demagogue. The proposal aimed at distribution of wealth in particular came in for convincing refutation, when the speaker cited statistics to show that if all individual salaries and incomes, in excess of $150,000 per year after taxes, were pooled and distributed equally throughout the country, every citizen would receive only 16 cents per month. If the limitation were lowered to salaries in excess of $5,000, individual payments would be only $2.32 per month. The increase in permanent unemployment that would result from such a preposterous scaling down of living standards, would be many times the present, for it would deal almost a death blow to construction and other heavy industries now already sorely affected.

Charles Belknap, chairman of the Executive Committee, reported on many significant activities of the Association during the past year. Of prime importance were the agreements concluded between the U. S. Public Health Service and the chemical producers for appropriate precautionary labeling of carbon tetrachloride and similar chlorinated hydrocarbons, carbon bisulphide, aniline oil and, most recently, benzol. The work of the technical committees on transportation problems and development of new containers is generally regarded of outstanding importance. Comprehensive study and prompt action in the case of state and federal legislative proposals has proved particularly effective according to Mr. Belknap in paying a tribute to the work of Secretary Warren N. Watson and his staff in the Washington office.

Reporting for the nominating committee, L. T. Beale, president of the Pennsylvania Salt Manufacturing Co. proposed and the meeting subsequently re-elected the present officers of MCA of which W. B. Bell is president, E. M. Allen and George W. Merck, vice-presidents, J. W. McLaughlin, treasurer and W. N. Watson, secretary.

The meeting went on record in resolutions condemning the pending Wagner Labor Relations Bill and certain features of the banking bill, particularly Title II that would put complete control of credit and monetary policies in political hands.

Of broadest economic interest were two addresses by outstanding authorities. Professor Neil Carothers of Lehigh University and Lewis W. Douglas, former director of the budget and now vice-president of the American Cyanamid Co.

Dr. Carothers condemned as poisonous economic propaganda, the "monstrous error that we live in an age of plenty, an era of abundance, the error that only exploitation prevents a rich living with little work for all." This error, he said, has done untold harm. "Out of it has come technocracy, the Townsend plan, Huey Long's share-the-wealth, the Reverend Coughlin's program, the 30-hour week, and nearly all of the New Deal."

While we have not yet attained and will not, in our time, reach such an age of plenty, nevertheless we move toward it. And in this progress toward an economic millennium, Professor Carothers feels that the chemical industries are going to be the leaders. "The past age has belonged to steam, steel and electricity, and they will still be fundamentally important, but in my judgment, the economic future lies in chemistry. Economic security does not lie in politicians juggling currencies but in chemists juggling molecules."

Professor Carothers then turned to the pending banking bill and pointed out the extreme dangers that lie in its proposed political control of the currency-credit-investment policies of the country.

Lewis W. Douglas, guest speaker at the joint dinner with the Synthetic Organic Chemical Manufacturers' Association, addressed himself to the subject "Collectivism vs. Individualism." The basic issue before the American people today, he said, is whether or not we elect to live in a competitive system for profit, with political and economic freedom for the individual or whether we want a collective system in which private property ceases to exist, where creative impulse disappears and liberty is gone. The pattern for the latter system has already been cast in this country by the New Deal, in exactly the sequence followed in the sovietization of Russia. The four steps employed there were (1) confiscation of gold, (2) centralization and control of banking, (3) socialization of bank deposits and (4) a policy of spending to currency destruction. The last step, declared by the Soviet Commissionaires to be most effective, is the one most imminent in this country according to Mr. Douglas. If we are to avoid collectivism in this country six fundamental factors must be maintained. (1) Free play of the profit system without any such artificial guarantees as NRA or AAA; (2) mobility of capital impossible under regimentation; (3) flexibility of costs to meet changing economic conditions; (4) unhampered international trade to prevent necessity of planned economy; (5) sound banking system and (6) a balanced budget.

Of these the last is most important according to Mr. Douglas because history has always shown that continued spending leads to destruction of currency and with it the impoverishment of the middle class. Despite the fact that the United States has shown an accumulated deficit since 1931 of $19 billion for relief and public works alone, it would still be possible to effect a balanced budget in the fiscal year 1937 if we abolish public works expenditures, liquidate RFC and PWA, curtail relief to $1.2 billion and hold taxes at $3.3 billion. Which, Mr. Douglas asks, is most inhumane, to balance the budget through such stringent measures or to spend into destruction the resources and freedom of 126,000,000 people?

NEWS FROM ABROAD

By Special Correspondents of Chem. & Met. at Berlin and Rome

Berlin

GERMAN production of crude oil in 1934 totaled 313,000 metric tons, compared with 233,000 tons in the preceding year. Once more the importance of the Nienhagen field was demonstrated, with an increase of 34.5 per cent over 1933; 77 per cent of the total German output came from this field. A systematic campaign, partly subsidized by the government, was carried out during the last year; 60 new wells, evenly distributed over the entire country, were drilled. The results of this survey have been so promising that the campaign is being continued this year. Good strikes have been made at 100 in. depth at Molme in Hannover and at Bruchsal in Baden, where the best crude oil in Germany is found, and where the tertiary strata resemble those at Pechelbronn in French Alsace.

Much interest is being displayed in the production of montan wax from lignite and its further refining. Annual production at present is about 10,000 to 12,000 tons. I. G. Farbenindustrie has done much work in this field and has succeeded in decomposing the montan wax into alcohols and fatty acid; the products thus obtained have very high elasticity, are easily emulsified, and possess excellent polishing properties. They are far better than the original wax for manufacturing shoe cream, furniture polishes, and polishing waxes. Montan wax bleached with chromic acid is not desirable for manufacture of shoe cream as the high content of organic acid imparts a tendency to crystallize. This difficulty is overcome by esterification with polyvolent alcohols, particularly if only a part is esterified, while the remainder is converted into alkali or alkaline earth salts, for instance calcium glycerine zinc ester plus calcium amylester. Such compounds have good oil-binding properties and are also easily dyed (German Patents 558,437 and 563,394). By addition of triethanol amine and similar compounds to esterified montan wax a preparation is obtained, according to R. Strauss, which is easily filled in tubes and which has no tendency to jell. (I. G. Farben, G. P. 565,966). New methods for refining montan wax developed by I. G. Farben include pressure hydrogenation of the fatty acids and esterification of the alcohols with organic acids, such as stearic, palmitic, naphthenic, or similar acids. The acid produced by the oxidation of the montan wax is reduced catalytically, in the form of methyl or ethyl ester; the alcohols thus produced are then esterified, alone or in the presence of uni or polyvolent esters of the organic acids mentioned. These new products are characterized by their ability to bind oil, by their hardness, homogeneity, and high polishing effect, and are used for making shoe creams and polishing compounds. (G. P. 559,631). A clear, hard wax with melting point of 85 deg. C. is made from montan wax esterified with methanol, by hydrogenation at 180 deg. C., using a 2 per cent nickel diatomaceous earth catalyst. Valuable waxes are also obtained from oils and fats such as olive oil, rapeseed oil, soya bean oil, codliver oil, according to I. G. Farben, by conducting the hydrogenation procedure in such a manner that the saponification value of the resulting products is not less than 15 per cent and not more than 85 per cent of that of the original material. The products are very hard and have a high polish and are used for polishing waxes, lubricants, candles, for finishing textiles. (G. P. 599,581, F. P. 709,860, B. P. 388,864). If the hydrogenation is carried to the point where the saponification value is O, then primary alcohols are formed from the normal fatty acids, while oxy fatty acids or carboxylic acids give polyvolent alcohols. These alcohols which now are produced on a commercial scale are capable of forming stable emulsions with soaps, and are particularly useful in connection with metals and fibers where fats, oils, and fatty acids cannot be used on account of their acid character. By sulphonation and amidation the alcohols may be converted into compounds which, when present as salts, produce soaps of high capillary power. These salts are resistant to lime and are therefore used in the textile industry and in washing wool.

Rhodium and rhenium, which belong to different groups in the periodic system, but which have much in common galvanotechnically, are now finding commercial application in plating. Both are nearly the same price, and as they are about the most expensive metals used for plating purposes they are limited to very thin coatings, which, on account of their exceptionally high corrosion resistance, serve as an effective protection for other metals or metallic coatings. Rhodium has become useful for protecting silver from tarnishing; a deposit of 0.0001 mm. thickness has been found sufficient for this purpose. Like platinum and palladium, it may be plated from an ammino nitrite bath $(Rh\ (NH_3)_4(NO_2)_2)$. A half minute flash is sufficient to protect silver, the amount deposited being 28 mg. per sq.dm. With a price of 10 Rm. per gram this gives 0.25—0.30 Rm. per sq.dm. Rhodium is also used for plating reflectors and optical mirrors. Rhenium is characterized by high resistance to hydrochloric acid; it is plated from a bath containing potassium perrhenate, in combination with perrhenic acid and sulphuric acid, or with phosphoric acid and sodium phosphate. A current density of 10-17 amp./sq.dm. is used, to reduce the plating time to a minimum; 1 to 1½ min. is generally sufficient. All rhenium baths possess good throwing power, better than chromium, and give highly lustrous deposit that requires no polishing. The resistance to hydrochloric acid is so great that rhenium plated brass articles submerged in this acid for three days showed no effect.

Rome

Chemical engineering in Italy has received much encouragement from the government lately; a special office has been created for the examination of inventions, and for the arrangement of prize competitions. Among recent new installations may be mentioned plants for the production of acetylene dissolved in acetone; for extraction of vanadium from combustion residues of naphtha; for production of oxalic acid and oxalates, tannic acid, ammonia and nitrates, explosives, lead oxide and lead salts, cobalt salts, and arsenic.

An interesting installation now in operation for more than twelve years is the Ragusa plant for production of mineral oil from rock asphalt, the present output of which is about 10,000 metric tons annually. The visible reserves of bituminous rock total about 375,000,000 tons; a daily supply of 6,666 tons is required for an annual production of 50,000 tons which will be the capacity of the plant upon completion of units now under construction.

The rock is crushed to a size of 8-10 in. and charged to furnaces where the hydrocarbons are driven off at a temperature of 420-450 deg. C. The resulting oil, which resembles a Texas or California crude, is very well suited for the production of lubricants.

Use of sulphur as a protective covering of vats, tubing, and other equipment for handling strong acids was patented in Italy in September, 1933; tests with

such equipment at the Biffi works in Milan have given excellent results. The sulphur used for this purpose is the crude product obtained in the first fusion of the ore; the thickness of the covering depends on the dimension of the apparatus to be lined, but should not be less than 3 cm. or more than 6 cm., 5 cm. being preferable under most conditions.

The sulphur is applied in molten condition, at a temperature not exceeding 118-120 deg. C. It is held in place by forms which are removed as soon as the sulphur is solidified. After solidification the surface is heated rapidly with a gasoline torch, to fuse a layer of 1-2 mm. at the surface; if necessary the surface is rubbed rapidly with a rag. Sometimes it is found advisable to apply the gasoline torch once more, this time at such a rapid speed that the sulphur will not run. These sulphur linings have been found useful for warm mineral acids, up to 65-70 deg. C. A vat at the Biffi works containing concentrated sulphuric acid at 65 deg. C. was found in excellent shape after several months' service.

Carbon Black Production Gained Last Year

THE carbon black industry, which had given indications of recovering from the depression in 1933, made marked progress in 1934. Although the indicated plant demand in 1934 was considerably under the total of 1933, prices were approximately 30 per cent higher. Production of carbon black in 1934 was 328,828,000 lb., an increase of 20 per cent over the output in 1933. Stocks at the plants which had shown a material decline in 1933, due to speculative buying before the anticipated rise in prices, increased approximately 16,000,000 lb. in 1934. The total on hand Dec. 31, 1934, was 171,799,000 or about 6 months' supply.

Sales of carbon black declined from 374,468,000 lb. in 1933 to 312,612,000 lb. in 1934, probably due to speculative buying on the part of customers in 1933. Of the total sales, 120,620,000 lb. (39 per cent) was exported and 191,992,000 lb. (61 per cent) was sold to domestic customers. Of the domestic sales, 165,446,000 lb. (86 per cent) was consigned to rubber companies, 16,146,000 lb. (8 per cent) to ink companies, 5,365,000 lb. (3 per cent) to paint companies, and 5,035,000 lb. (3 per cent) to companies producing miscellaneous products.

Effective Jan. 1, 1934, a new series of carbon black prices were posted; in general, these represented increases over the levels of 1933. The average value of carbon black at the plants advanced from 2.78 cents in 1933 to 3.54 cents in 1934, the total value increased from $7,602,000 in 1933 to $11,654,000 in 1934.

Sales of Carbon Black

	1933	1934
Domestic:		
To rubber companies	191,358,000	165,446,000
To ink companies	18,539,000	16,146,000
To paint companies	6,260,000	5,365,000
To miscellaneous companies ...	6,025,000	5,035,000
Total	222,182,000	191,992,000
Exports:		
United Kingdom	42,604,000	37,697,000
France	32,417,000	22,726,000
Germany	20,327,000	16,499,000
Other	56,938,000	43,698,000
Total	152,286,000	120,620,000

Bagilumbang Tree Source Of Paint Oil

THE bagilumbang tree, brought here from the Philippines, may prove a rival of the tung tree, also brought here from the Far East. Both produce nuts that are sources of oils for use in paint and varnish. The tung tree is already established in Florida where it does well in a limited area on acid soils. The bagilumbang grows well on limy soils as well as on acid soils, and for that reason has a wider area open to it in the warmer parts of the Gulf States.

The seeds of the bagilumbang tree supply a good drying oil very similar to tung oil, Dr. G. S. Jamieson and R. S. McKinney of the Bureau of Chemistry and Soils, reported at the recent meeting of the American Oil Chemists Society at Memphis. Bagilumbang culture has possibilities as a farm enterprise on limy soils where tung trees do not flourish.

Like tung oil, they reported the oil from the bagilumbang tree has marked drying qualities and ingredients similar to those which make tung oil of value for the manufacture of varnish, floor paint, enamel paint, and paint driers. For many years the Philippine natives have used the oil of the bagilumbang tree for painting their boats.

A.P.I. Will Not Sponsor World Petroleum Congress

THE American Petroleum Institute has informed the Institution of Petroleum Technologists at London, England, that it cannot accept an invitation to sponsor a World Petroleum Congress in the United States in 1936.

The Institute's president, Axtell J. Byles, informed the Institution that the organization regretted the necessity for declining the invitation, adding that visitors from the British group and others of a similar nature would be assured cordial welcomes at Institute meetings.

The first World Petroleum Congress was held at London last year, and was attended by American technologists.

Committee Named to Promote Use of Farm Products

FOLLOWING the conference held at Dearborn, Mich., on May 7-8, which was attended by representatives of agriculture, industry, and science and which had for its purpose the development of farm products into chemicals, it is now announced that members of the three groups have been named as members of a permanent organization committee by Francis P. Garvan, president of the Chemical Foundation and chairman of the recent conference.

The committee includes: Louis J. Taber, master, The National Grange; D. Howard Doane, president, American Society of Farm Managers; R. H. McCarroll, chief chemist, Ford Motor Co.; Fred W. Sargent, president, Chicago and North Western Railway Co.; Clifford V. Gregory, editor, *The Prairie Farmer*; Dr. Roger Adams, president, American Chemical Society; Dr. Charles H. Herty, director, Pulp and Paper Laboratory; Col. Frank Knox, publisher, *The Chicago Daily News*; Howard E. Coffin, chairman, Southeastern Cottons, Inc.; W. B. Bell, president, American Cyanamid Co.; Dr. William J. Hale, chemist, Dow Chemical Co.; William W. Buffum, treasurer, The Chemical Foundation, Inc.; Dr. Charles M. A. Stine, vice-president, E. I. duPont de Nemours & Co.; Wheeler McMillen, editor, *The Country Home*.

Italy Will Use Alcohol As Motor Fuel

TO reduce Italy's dependence upon outside sources for motor fuels, the Beet and Sugar Corp. recently presented a plan to the Central Corporative Committee to increase production of alcohol suitable for use in motors, according to a report from the Commerce Department's office in Rome.

According to the plan, production would be increased to one million hectoliters within four years and proposes that it shall be made obligatory for producers and importers of motor fuels to use sufficient alcohol mixed with gasoline to absorb the increased production.

The plan calls for the creation of a central purchasing and distributing office which would acquire all alcohol produced and distribute it to importers and producers of gasoline at prices fixed by the state.

The contemplated output in 1935 would be from 100,000 to 150,000 hectoliters; 1936, 500,000 hectoliters; 1937, 800,000 hectoliters; and 1938, 1,000,000. An output of one million hectoliters of alcohol will require a 50 per cent increase in the present sugar beet acreage, according to estimates.

NAMES *in the News*

J. G. Hildebrand, Jr., has joined the staff of Gustavus J. Esselen, Inc. Since receiving his Ph.D. from Columbia University in 1933, Dr. Hildebrand has been engaged in research and consultation at New York. In his new connection he will have charge of the new laboratory devoted to the application of electronics to industry.

Leon E. Hunter is employed as chemist by the Titanium Pigments Co. at Sayreville, N. J.

B. Morris Kratz is now associated with Philip Morris and Co., New York.

Nelson Littell, of the patent law firm of Hammond & Littell, sailed on the *Albert Ballin* May 30 for a six weeks' trip to Germany on business for the American Hyalsol Corp.

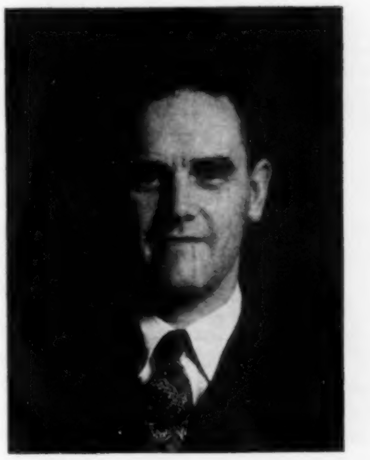
J. Moore Samuel has opened an office for consulting services in the Roosevelt Building, Los Angeles, Calif.

Ephraim Freedman, of R. H. Macy & Co., has been elected chairman of the New York Section of the American Association of Textile Chemists and Colorists. Other officers are: George L. Baxter, of the Bradford Dyeing Association; Patrick J. Kennedy, of E. I. duPont de Nemours & Co., and John J. Sokolinski, of Arobol Manufacturing Co.

William Cabler Moore, of the U. S. Industrial Alcohol Co., has been elected chairman of the New York Section of the Electrochemical Society. H. E. Haring, of the Bell Telephone Laboratories, is the new secretary.

J. C. Woodruff has announced his resignation as research director of Commercial Solvents Corp., a position he has occupied for the past two years. For the time being he is making headquarters at his summer vacation residence, Meadow Camp, Willsboro, N. Y.

William A. Hamor, assistant director of Mellon Institute of Industrial Research, received the honorary degree of Doctor of Science from the University of Pittsburgh, June 5.



John Layton Bray

John Layton Bray has been appointed head of the School of Chemical Engineering at Purdue University, to succeed Prof. H. C. Peffer, who died last summer. Dr. Bray is a graduate of Massachusetts Institute of Technology, with degrees in mining and metallurgical engineering. From 1912 to 1922 he was connected with mining and metallurgical industries of three continents. Since that time he has held the position of professor of metallurgy at Purdue.

Manly M. Windsor is now associated with Harshaw Chemical Co., doing plant development work at the Elyria plant. He was formerly an instructor in the department of chemistry at Massachusetts Institute of Technology.

Vernon H. Schnee has been appointed by Clyde E. Williams to the staff of Battelle Memorial Institute. Mr. Schnee will be employed in the development of inhibitors, lubricants and non-ferrous alloys.

John M. Whitaker has become associated with the Atlas Corp., Jersey City, N. J., as an industrial engineer.

Sheppard T. Powell, Baltimore, Md., has resigned the chairmanship of the Boiler Feed Water Studies Committee of the American Water Works Association. C. H. Fellows, of the Detroit Edison Co., succeeds him.

R. L. Hallett of the National Lead Co., Brooklyn, N. Y., has been nominated a member of the executive committee of the American Society for Testing Materials. He will serve two years.

George Sivola, formerly chief chemist of the Dexter Pulp and Paper Co., Dexter, N. Y. is now with Enso Gutzeit, Enso, Finland.

OBITUARY

Thomas C. Meadows died in New York on May 3 after a brief illness. He was born in Tennessee in 1871 and was one of the pioneer developers of the phosphate rock industry of that state.

William H. Smith, president and general manager of the Pioneer Alloy Products Co., died on June 3. He was one of the pioneers in the alloy casting industry.

Edward Allen Colby died suddenly of a heart attack at his home in Maplewood, N. J., on June 1. He was 78 years old. Mr. Colby was born at St. Johnsbury, Vt., and was graduated from Yale University in 1880. Two years later he became associated with Dr. Edward Weston at Newark, N. J. He invented an induction electric furnace, for which he received a medal from the Franklin Institute. About 1900 he became chief engineer and superintendent of the Newark plant of the Baker Platinum Works. He retired from that position in 1930, however, and at the time of his death he was secretary and consulting engineer for the company.

CALENDAR

American Society for Testing Materials, annual meeting, Detroit, June 24-28.

American Chemical Society, San Francisco, week of Aug. 19.

Technical Association of the Pulp and Paper Industry, fall meeting, Atlantic City, week of Sept. 16.

Electrochemical Society, semi-annual meeting, Washington, D. C., Oct. 10-12.

American Petroleum Institute, annual meeting, Los Angeles, Nov. 11-14.

American Institute of Chemical Engineers, annual meeting, Columbus, Ohio, Nov. 13-15.

Exposition of Chemical Industries, New York, week of Dec. 2-7.

Chemical ECONOMICS

REGULAR survey of wages, hours and employment of the National Industrial Conference Board reveals an 0.8 per cent increase in manufacturing activity for April over March, resulting from an increase of 0.5 per cent in the number of employed workers and an advance of 0.3 per cent in the average number of working hours for each wage earner.

Both weekly and hourly earnings gained in April, the former by 0.3 per cent and the latter by 0.2 per cent. Real weekly earnings were 0.6 per cent lower in April than in March, while pay roll disbursements were 0.9 per cent greater.

Comparison of conditions in April with those of April, 1934, shows that total pay roll disbursements were 3.9 per cent larger this year; average hourly earnings 2.9 per cent higher.

A moderate recession from the spring peak of business activity was reported by the Commerce Department.

In its "survey of current business" it stated that output of manufacturing industries increased by the usual seasonal amount during April, but that the index of industrial production declined because of a sharp drop in mineral production.

Available weekly data for May do not indicate a change in the trend, the report said. Automobile output has been curtailed; steel ingot production has declined further; cotton cloth production has continued near the lower level reached at the end of April, and lumber production has been reduced by labor difficulties which were encountered in the Pacific Coast area.

Among the lines listed as having made gains in April were the automobile, tobacco manufacturing, leather and shoe, plate glass, cement and machine tool industries. A further substantial drop in iron and steel production and declines in production of silk and cotton goods and rayon shipments were shown for the same month. Operations of the woolen industry during April were said to have continued at a high rate.

Data are not available for production and sales of most of the materials which enter into paint manufacture, but trade advices are to the effect that the increase over the corresponding period is considerable and is general. Sales of carbon black, especially, are noteworthy, because of the better showing made so far this year.

Paint Sales Increase

Sales of paint, varnish and lacquer products during April touched the highest total in several years, amounting to \$33,721,326, as against \$27,332,504 in March, and compared with \$27,703,643 and \$19,043,787 in April of 1934 and 1933. The total also ran ahead of May, 1934, which was the best month of last year, sales aggregating \$33,614,819.

In addition to the figures for sales of paint, varnish, and lacquer the Bureau of the Census has issued a report on sales of lacquer for the first quarter of this year. The total for sales, which includes clear lacquers, pigment lacquers, lacquer bases and dopes, and thinners is 8,219,934 gal. with a value of \$10,599,995. Comparable figures for sales in the first quarter of 1934 are not available. On a valuation basis, sales of lacquer products in the first quarter of this year amounted to about 15 per cent of the total reported for the entire group of paint, varnish and lacquer.

Latest figures regarding sulphuric acid in the fertilizer trade indicate that production of the acid continues to hold above the rate for the comparable period of last year while consumption of the acid in making fertilizer holds below last year's total. As a result of this condition fertilizer manufacturers had shipped 156,514 tons of acid to buyers outside the fertilizer trade in the first four months of this year as compared with shipments of 114,363 tons in the Jan.-April period of 1934. Purchases of acid from non-fertilizer manufacturers in the same period amounted to 81,504 tons and 107,257 tons in 1935 and 1934 respectively.

In the field of plastics, the outstanding development is found in the sharp rise in production of cellulose acetate plastics. The output for the first five months of this year is reported to have exceeded that for the entire 12 months of 1934. Shipments have practically kept pace with production, so there has been no accumulation of stocks in sellers' hands.

Rayon deliveries which were on the downward trend in March and part of April picked up materially in the latter half of April and May shipments showed a very large gain over those for the preceding month. In some cases June outputs were fully sold ahead by the first of the month and different plants were reported to be operating again at full plant capacity.

Production of polished plate glass by member companies of the Plate Glass Manufacturers of America established a new record in April at 16,998,914 sq.ft. This compares with output of 16,531,950 sq.ft. in March, the previous record, and 8,629,381 sq.ft. in April, 1934.

The textile industry has not changed materially during the month. Cotton consumption in May was a little lower than in April and also compares unfavorably with the figure for May, 1934.

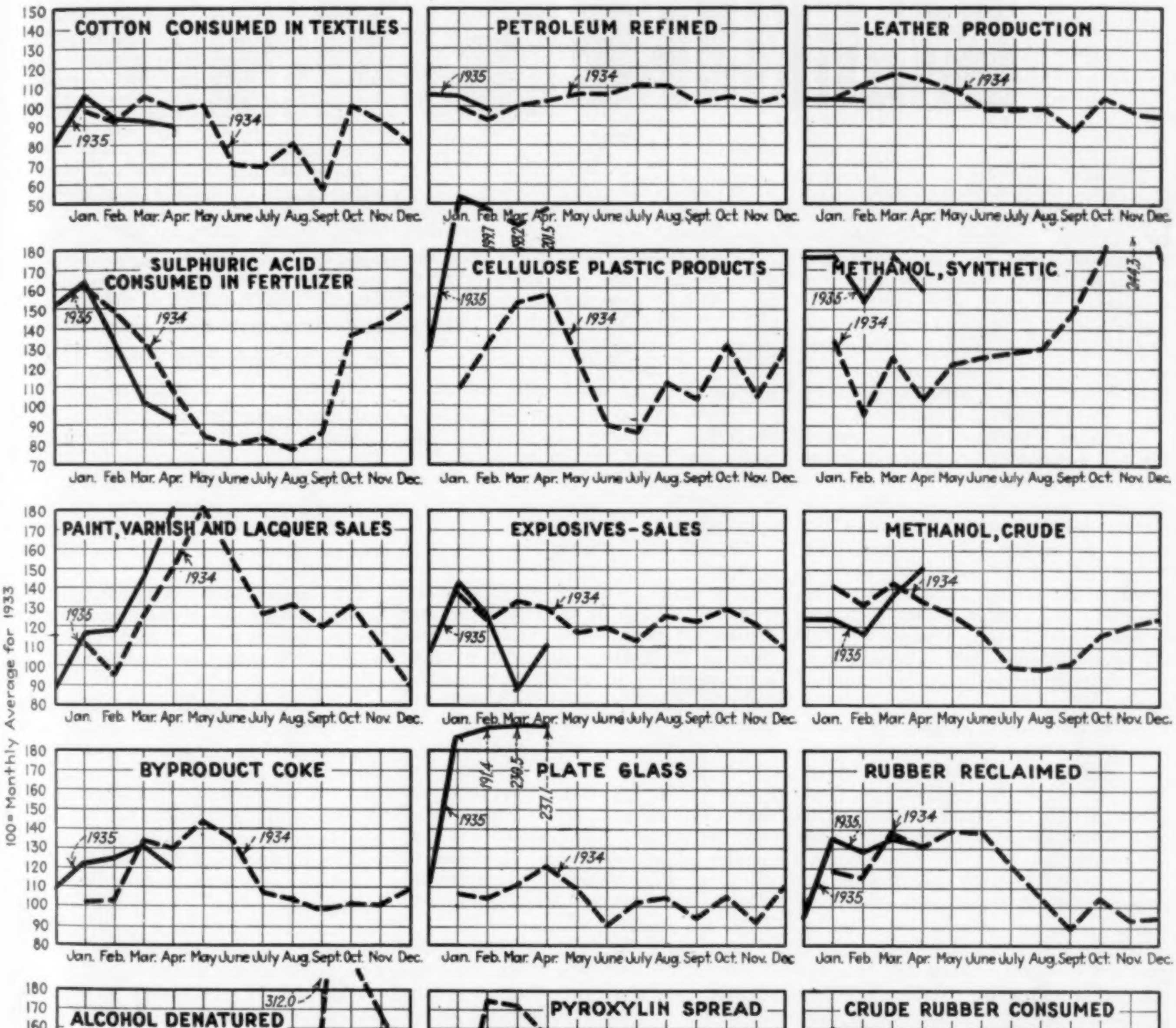
Consumption of crude rubber by manufacturers in United States in April amounted to 44,714 long tons, which compares with 42,620 long tons for March, 1935. April consumption shows an increase of 4.9 per cent above March and practically no change as compared with April, 1934, according to statistics released by the Rubber Manufacturers' Association. Consumption for April, 1934, was reported to be 44,853 long tons.

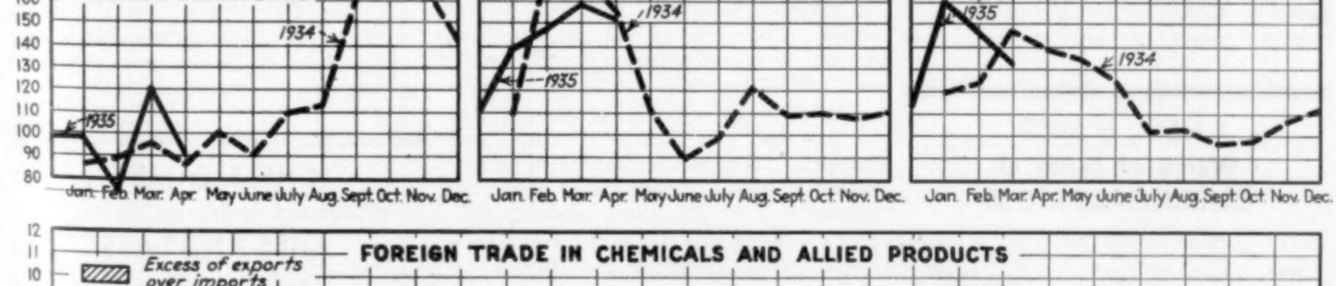
Production and Consumption Data for Chemical-Consuming Industries

	April 1935	April 1934	Jan.-April 1935	Jan.-April 1934	Per Cent of Gain Jan.-April, 1935 Over Jan.-April, 1934
Production					
Alcohol, denatured 1,000 wi. gal	5,554	5,259	23,666	21,849	8.3
Automobiles, No.	477,716	352,975	1,536,066	1,077,331	42.6
Byproduct coke, 1,000 tons	2,670	2,875	11,164	10,713	4.2
Glass containers, 1,000 gr	3,113	3,037	11,633	11,327	2.7
Plate glass, 1,000 sq. ft	16,999	8,629	60,619	33,605	80.3
Methanol, crude, gal	386,006	342,307	1,353,465	1,407,164	3.8*
Methanol, synthetic, gal	1,167,282	754,980	4,900,482	3,342,499	46.6
Nitrocellulose plastics, lb	1,311,038	1,383,754	5,608,536	4,918,388	14.0
Cellulose-acetate plastics, lb	1,106,845	510,225	3,994,316	1,709,031	133.7
Pyroxylin spread, 1,000 lb	4,600	4,258	18,087	18,018	0.4
Rubber reclaimed, tons	10,315	10,185	41,401	39,147	5.7
Steel barrels, No.	614,385	657,185	1,979,392	2,634,421	24.8*
Sulphuric acid produced by fertilizer manufacturers, tons	139,333	119,619	604,345	535,594	12.8
Consumption					
Cotton, 1,000 bales	463	513	1,969	2,043	3.6*
Explosives, sales, 1,000 lb	23,202	26,958	96,912	108,771	10.9*
Paint, varnish and lacquer, sales, \$1,000	33,721	27,704	104,471	89,113	17.2
Sulphuric acid in fertilizer trade, tons	93,873	107,842	493,891	552,561	11.9*

*Per cent of decline.

TRENDS OF PRODUCTION AND CONSUMPTION





The MARKETS

DELIVERIES of chemicals against existing contracts held up well throughout May. In some cases, call for materials was better than had been expected. The paint, glass, and rubber trades were reported to have taken full allotments. The turn of the month brought about a quieter condition and June delivery of raw materials promises to show a drop from the total for May.

The effect of the court decision regarding NRA caused a brief period of uncertainty but its direct effect on the chemical industry is not regarded as important from a trading standpoint so long as consuming industries are undisturbed. The price situation, however, appears to be a little weaker, partly because of belief that producing costs may be lowered and partly because some of the basic materials, such as metals, have sold at lower prices in the last week or more.

Although it now appears that existing excise taxes will be extended and new ones will be sought by the Administration from this session of Congress, there is still considerable question whether the extensions will affect chemical products.

The Byrd-Bland bill providing for extension of the fats and oils excise taxes remains dormant, although its sponsors insist that they will have plenty of pressure for it when revenue bill hearings open. The bill would extend the 3 cent per pound tax on marine oils to fatty acids of such oils, and would levy a $\frac{1}{8}$ cent per pound tax on fish scrap, fish meal, marine animal scrap and marine animal meal.

Proposals for excise taxes on pulpwood do not have as favorable prospects as those proposed for the fats and oils. Representative Smith of Virginia has a bill pending that levy taxes of $2 per cord on pulpwood, $7.50 per short ton on chemical wood pulp, and $4.50 per short ton on mechanically ground wood pulp. This proposal will draw support from North Pacific representatives and probably from the Southern States interested in development of the yellow pine industry.

Another bill pending that has good prospects if only time can be found for its passage is a bill introduced by Representative Deen of Georgia providing for annual publication by the Department of Agriculture of statistics relating to quantity of spirits of turpentine and rosin produced, held and used in the country.

Official formula number five for completely denatured alcohol has been repealed by the Treasury Department because enforcement agents have found that the product made under it is susceptible to cleansing and diversion to illicit beverage channels, according to officials of the Alcohol Tax Unit of that body.

At present, the technical staff of the Alcohol Tax Unit has under consideration a number of formulas for substitution for the one repealed, but as yet no decision has been reached. Meanwhile, producers of the product are limited to manufacture under the other two official formulas of the department.

On May 25 a trade agreement was signed by the United States and Sweden. This is the fifth trade agreement to have been negotiated under the authority granted to the President. Previous agreements concluded were with Cuba, Brazil, Belgium, and Haiti.

The concessions granted by the United States to Sweden are of three types: (a) Engagements to continue the present free entry of certain articles, (b) engagements not to increase the present rates of duty on certain articles, and (c) reductions in certain existing duties.

The most important reductions in duty made by the United States relate to certain high-priced classes of iron and steel, wrapping paper, processed paper board, and matches. Several of the articles on which reductions are made are virtually noncompetitive, there being little or no domestic production. Most of the other reduced rates are on articles of which the imports have hitherto been insignificant in comparison with domestic production. Although the imports of these are likely to increase under the reduced duties, there is no probability that they will become large enough to have any appreciable effect on domestic industries.

The Bureau of Chemistry and Soils, from its compilation of information furnished by the manufacturers of turpentine cups, reports that a total of 6,219,240 cups sold last winter and this spring for use in gathering the 1935-36 crop of naval stores. The total number of cups sold is 5,488,599 less than was purchased for the 1934-35 crop. Average cup sales over a period of thirteen years approximate 14,071,036.

The board of managers of the New York Produce Exchange has approved the rules for futures trading in tallow on that exchange. The unit of trading will be 60,000 lb.

Interest in potash has been heightened by the announcement that the industry has formed an institute to stimulate research work and to increase consumption of potash.

Headquarters of the Institute will be in Washington, D. C., from which point research and the preparation of educational literature will be directed. The Institute will, however, not establish any experimental laboratories of its own. The research work which it will finance will be done altogether in established institutions under State, Federal, or private management. Close cooperation with the other scientific and trade organizations, including National Fertilizer Association, is planned. At the outset, branch offices will be established in existing laboratories at Atlanta, Ga., Lafayette, Ind., San Jose, Calif., and Hamilton, Ontario. No investigations on production methods or on the trade aspects of the industry are contemplated.

CHEM. & MET. Weighted Index of CHEMICAL PRICES

Base = 100 for 1927

This month	**87.45**
Last month	87.62
June, 1934	88.35
June, 1933	85.37

As a rule prices for chemicals were unchanged during the last month. The metal salts were strengthened by the rise in metal prices but eased off later in the period. Turpentine was lower and was largely instrumental in reducing the index number.

CHEM. & MET. Weighted Index of Prices for OILS AND FATS

Base = 100 for 1927

This month	**92.90**
Last month	94.14
June, 1934	57.48
June, 1933	55.73

Animal fats held a strong position throughout but vegetable oils showed a spotty condition with crude cottonseed oil leading in a downward price trend.

Current PRICES

The following prices refer to round lots in the New York market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to June 13.

Industrial Chemicals

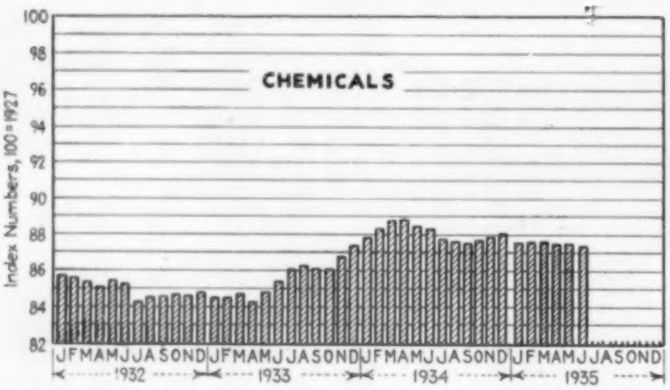
	Current Price	Last Month	Last Year
Acetone, drums, lb	$0.12 -$0.12½	$0.12 -$0.12½	$0.11 -$0.11½
Acid, acetic, 28%, bbl., cwt	2.45 - 2.70	2.40 - 2.65	2.90 - 3.15
Glacial 99%, drums	8.43 - 8.68	8.25 - 8.50	10.02 -10.27
U. S. P. reagent	10.52 -10.77	10.52 -10.77	10.52 -10.77
Borie, bbl., lb	.04¾- .05	.04¾- .05	.04¾- .05
Citric, kegs, lb	.28 - .31	.28 - .31	.28 - .31
Formic, bbl., lb	.11 - .11½	.11 - .11½	.11 - .11½
Gallic, tech., bbl., lb	.60 - .65	.60 - .65	.60 - .65
Hydrofluoric 30% carb., lb	.07 - .07½	.07 - .07½	.07 - .07½
Latic, 44%, tech., light, bbl., lb	.12 - .12½	.12 - .12½	.11½- .12
22%, tech., light, bbl., lb	.06½- .07	.06½- .07	.06 - .06½
Muriatic, 18° tanks, cwt	1.00 - 1.10	1.00 - 1.10	1.00 - 1.10
Nitric, 36°, carboys, lb	.05 - .05½	.05 - .05½	.05 - .05½
Oleum, tanks, wks., ton	18.50 -20.00	18.50 -......	18.50 -20.00
Oxalic, crystals, bbl., lb	.11¾- .12¾	.11¾- .12¾	.11¾- .12¾
Phosphoric, tech., c'bys., lb	.09 - .10	.09 - .10	.09 - .10
Sulphuric, 60°, tanks, ton	11.00 -11.50	11.00 -11.50	11.00 -11.50
Sulphuric, 66°, tanks, ton	15.50 -......	15.50 -......	15.50 -......
Tannic, tech., bbl., lb	.23 - .35	.23 - .35	.23 - .35
Tartaric, powd., bbl., lb	.24 - .25	.24 - .25	.26 - .26½
Tungstic, bbl., lb	1.50 - 1.60	1.40 - 1.50	1.40 - 1.50
Alcohol Amyl	......-......	......-......	......-......
From Pentane, tanks, lb	.15 -......	.15 -......	.143-......
Alcohol Butyl, tanks, lb	.13 -......	.13 -......	.095-......
Alcohol, Ethyl, 190 p'f., bbl., gal	4.27½-......	4.27½-......	4.15½-......
Denatured, 190 proof			
No. 1 special, dr., gal	.36 -......	.36 -......	.346-......
No. 5, 188 proof, dr., gal	.35½-......	.35½-......	.34 -......
Alum, ammonia, lump, bbl., lb	.03 - .04	.03 - .04	.03 - .04
Chrome, bbl., lb	.04½- .05	.04½- .05	.04½- .05
Potash, lump, bbl., lb	.03 - .04	.03 - .04	.03 - .04
Aluminum sulphate, com., bags cwt	1.35 - 1.50	1.35 - 1.50	1.35 - 1.50
Iron free, bg., cwt	1.90 - 2.00	1.90 - 2.00	1.90 - 2.00
Aqua ammonia, 26°, drums lb	.02½- .03	.02½- .03	.02½- .03
tanks, lb	.02½- .02¾	.02½- .02¾	.02½- .02¾
Ammonia, anhydrous, cyl., lb	.15½- .16	.15½- .16	.15½- .16
tanks, lb	.04½-......	.04½-......	.04½-......
Ammonium carbonate powd tech., casks, lb	.08 - .12	.08 - .12	.08 - .12
Sulphate, wks., cwt	1.20 -......	1.20 -......	.125-......
Amylacetate tech., tanks, lb	.142-......	.142-......	.143-......
Antimony Oxide, bbl., lb	.11¾- .12	.11¾ - .12	.08¾- .09
Arsenic, white, powd., bbl., lb	.03½- .04	.03½- .04	.04 - .04½
Red, powd., kegs, lb	.15¾- .16	.15¾- .16	.15 - .15½
Barium carbonate, bbl., ton	56.50 -58.00	56.50 -58.00	56.50 -58.00
Chloride, bbl., ton	72.00 -74.00	74.00 -75.00	74.00 -75.00
Nitrate, cask, lb	.08½- .09	.08½- .09	.08½- .09
Blanc fixe, dry, bbl., lb	.03½- .04	.03½- .04	.03½- .04
Bleaching powder, f.o.b., wks drums, cwt	1.90 - 2.00	1.90 - 2.00	1.85 - 2.00
Borax, grain, bags, ton	40.00 -45.00	40.00 -45.00	40.00 -45.00
Bromine, cs., lb	.36 - .38	.36 - .38	.36 - .38
Calcium acetate, bags	2.10 -......	2.00 -......	3.00 -......
Arsenate, dr., lb	.06 - .07	.06 - .07	.05 - .06
Carbide drums, lb	.05 - .06	.05 - .06	.05 - .06
Chloride, fused, dr., del., ton	20.00 -33.00	20.00 -33.00	17.50 -......
flake, dr., del., ton	22.00 -35.00	22.00 -35.00	19.50 -......
Phosphate, bbl., lb	.07½- .08	.07½- .08	.07½- .08
Carbon bisulphide, drums, lb	.05½- .08½	.05½- .06	.05½- .06
Tetrachloride drums, lb	.05¾- .08½	.05¾- .06	.05¾- .06
Chlorine, liquid, tanks, wks., lb	2.00 -......	2.00 -......	.0185-......
Cylinders	.05½- .06	.05½- .06	.05½- .06
Cobalt oxide, cans, lb	1.25 - 1.30	1.25 - 1.30	1.35 - 1.40

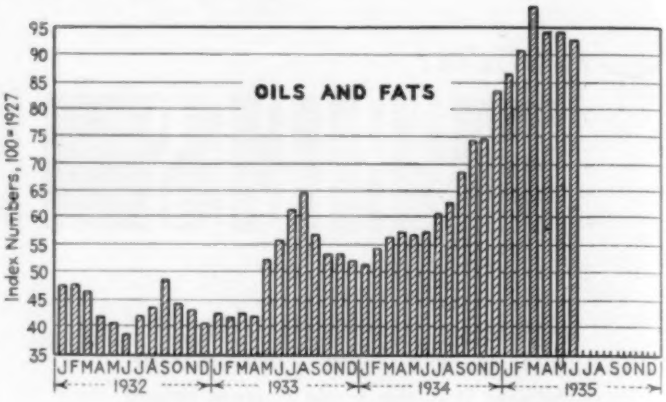
	Current Price	Last Month	Last Year
Copperas, bgs., f.o.b. wks., ton	14.00 -15.00	14.00 -15.00	14.00 -15.00
Copper carbonate, bbl., lb	.08¾- .16	.08¾- .16	.08¾- .16
Cyanide, tech., bbl., lb	.37 - .38	.37 - .38	.39 - .40
Sulphate, bbl., cwt	3.85 - 4.00	3.85 - 4.00	3.85 - 4.00
Cream of tartar, bbl., lb	.16¾ .17	.16¾- .17	.19¾- .20
Diethylene glycol, dr., lb	.16½- .20½	.16½- .20½	.14 - .16
Epsom salt, dom., tech., bbl., cwt	2.10 - 2.15	2.10 - 2.15	2.10 - 2.15
Imp., tech., bags, cwt	2.00 - 2.10	2.00 - 2.10	2.00 - 2.10
Ethyl acetate, drums, lb	.08½-......	.08½-......	.08½-......
Formaldehyde, 40%, bbl., lb	.06 - .07	.06 - .07	.06 - .07
Furfural, dr., contract, lb	.10 - .17½	.10 - .17½	.10 - .17½
Fusel oil, crude, drums, gal	.75 -......	.75 -......	.75 -......
Refined, dr., gal	1.25 - 1.30	1.25 - 1.30	1.25 - 1.30
Glaubers salt, bags, cwt	1.00 - 1.10	1.00 - 1.10	1.00 - 1.10
Glycerine, c.p., drums, extra, lb	.14 - .14½	.14 - .14½	.13½- .14
Lead:			
White, basic carbonate, dry casks, lb	.06½-......	.06½-......	.06½-......
White, basic sulphate, sck., lb	.06 -......	.06 -......	.06 -......
Red, dry, sck., lb	.06¾-......	.06½-......	.06½......
Lead acetate, white crys., bbl., lb	.10½- .11	.10½- .11	.10½- .11
Lead arsenate, powd., bbl., lb	.09 - .10	.09 - .10	.09 - .13
Lime, chem., bulk, ton	8.50 -......	8.50 -......	8.50 -......
Litharge, pwd., csk, lb	.05¾-......	.05 -......	.05½-......
Lithophone, bags, lb	.04½- .05	.04½- .05	.04½- .05
Magnesium carb., tech., bags, lb	.06 - .06½	.06 - .06½	.06- .06½
Methanol, 95%, tanks, gal	.33 -......	.33 -......	.33 -......
97%, tanks, gal	.34 -......	.34 -......	.34 -......
Synthetic, tanks, gal	.35½-......	.35½-......	.35½-......
Nickel salt, double, bbl., lb	.12½- .13	.12½- .13	.11½- .12
Orange mineral, csk., lb	.09¾-......	.09 -......	.09¾-......
Phosphorus, red, cases, lb	.44 - .45	.44 - .45	.45 - .46
Yellow, cases, lb	.28 - .32	.28 - .32	.28 - .32
Potassium bichromate, casks, lb	.07¾- .08½	.07¾- .08½	.07¾- .08½
Carbonate, 80-85%, calc. csk., lb	.07 - .07½	.07 - .07½	.07 - .07½
Chlorate, powd., lb	.08¾- .09	.08¾- .09	.09½- .10
Hydroxide (c'stic potash) dr., lb	.06½- .06½	.06½- .06½	.07½- .08
Muriate, 80% bgs., ton	22.00 -......	22.00 -......	31.90 -......
Nitrate, bbl., lb	.05½- .06	.05½- .06	.05½- .06
Permanganate, drums, lb	.18½- .19	.18½- .19	.18½- .19
Prussiate, yellow, casks, lb	.18 - .19	.18 - .19	.18 - .19
Sal ammoniac, white, casks, lb	.04½- .05	.04½- .05	.04½- .05
Salsoda, bbl., cwt	1.00 - 1.05	1.00 - 1.05	1.00 - 1.05
Salt cake, bulk, ton	13.00 -15.00	13.00 -15.00	13.00 -15.00
Soda ash, light, 58%, bags, contract, cwt	1.23 -......	1.23 -......	1.23 -......
Dense, bags, cwt	1.25 -......	1.25 -......	1.25 -......
Soda, caustic, 76%, solid, drums, contract, cwt	2.60 - 3.00	2.60 - 3.00	2.60 - 3.00
Acetate, works, bbl., lb	.04¾- .05	.04¾- .05	.04¾- .05
Bicarbonate, bbl., cwt	1.85 - 2.00	1.85 - 2.00	1.85 - 2.00
Bichromate, casks, lb	.05½- .06¾	.05½- .06¾	.05½- .06¾
Bisulphate, bulk, ton	15.00 -16.00	15.00 -16.00	14.00 -16.00
Bisulphite, bbl., lb	.03½- .04	.03½- .04	.03 - .04
Chlorate, kegs, lb	.06½- .06½	.06½- .06½	.06½- .06½
Chloride, tech., ton	12.00 -14.75	12.00 -14.75	12.00 -14.75
Cyanide, cases, dom., lb	.15½- .16	.15½- .16	.15½- .16
Fluoride, bbl., lb	.07½- .08	.07½- .08	.07½- .08
Hyposulphite, bbl., lb	2.40 - 2.50	2.40 - 2.50	2.40 - 2.50
Metasilicate, bbl., cwt	3.25 - 3.40	3.25 - 3.40	3.25 - 3.40
Nitrate, bags, cwt	1.275-......	1.275-......	1.35 -......
Nitrite, casks, lb	.07½- .08	.07½- .08	.07½- .08
Phosphate, dibasic, bbl., lb	.023- .024	.022- 0.24	.021- .023
Prussiate, yel. drums, lb	.11½- .12	.11½- .12	.11½- .02
Silicate (40° dr.) wks. cwt	.80 - .85	.80 - .85	.80 - .85
Sulphide, fused, 60-62%, dr., lb	.02¾- .03½	.02¾- .03	.02¾- .03
Sulphite, cyrs., bbl., lb	.02¾- .02½	.02¾ .02½	.03 - .03½
Sulphur, crude at mine, bulk, ton	18.00 -......	18.00 -......	18.00 -......
Chloride, dr., lb	.03½- .04	.03½- .04	.03½- .04
Dioxide, cyl., lb	.07 - .07½	.07 - .07½	.07 - .07½
Flour, bag, cwt	1.60 - 3.00	1.60 - 3.00	1.60 - 3.00
Tin Oxide, bbl. lb	.54 -......	.53 -......	.56 -......
Crystals, bbl., lb	.38½-......	.38 -......	.39 -......
Zinc chloride, gran., bbl., lb	.05 - .06	.05 - .06	.05½- .06
Carbonate, bbl., lb	.09½- .11	.09½- .11	.09½- .11
Cyanide, dr., lb	.36 - .38	.38 - .42	.38 - .42
Dust, bbl., lb	.059- .07	.059- .07	.07 - .07½
Zinc oxide, lead free, bag, lb	.05¾-......	.05¾-......	.06½-......
5% lead sulphate, bags, lb	.05½-......	.05½-......	.06½-......
Sulphate, bbl., cwt	2.75 - 3.00	2.75 - 3.00	3.00 - 3.25

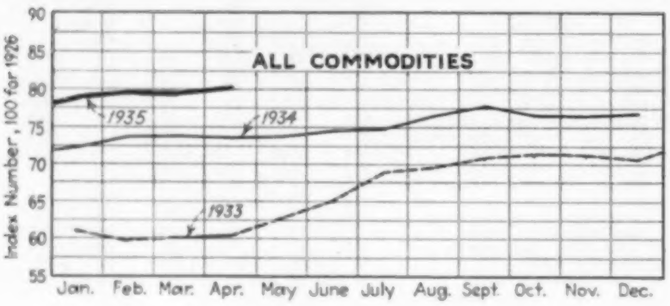
Oils and Fats

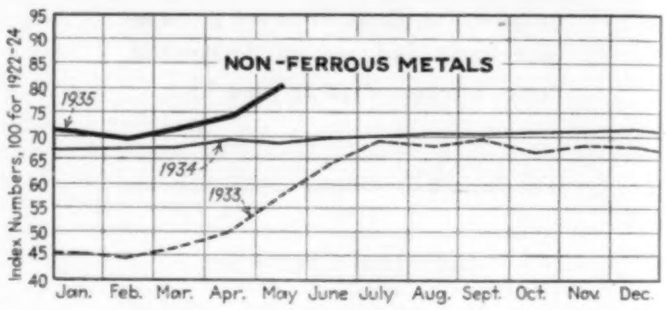
	Current Price	Last Month	Last Year
Castor oil, No. 3, bbl., lb	$0.09½-$0.10	$0.09½-$0.10	$0.09½-$0.10
Chinawood oil, bbl., lb	.18 -......	.17 -......	.09½-......
Coconut oil, Ceylon, tanks, N. Y. lb	.04¾-......	.05½-......	.02¾-......
Corn oil crude, tanks, (f.o.b. mill), lb	.08¾-......	.08¾-......	.04½-......
Cottonseed oil, crude (f.o.b. mill), tanks, lb	.09 -......	.09½-......	.04½-......
Linseed oil, raw car lots, bbl., lb	.097-......	.095-......	.099-......
Palm, casks, lb	.04½-......	.04½-......	.03½-......
Palm Kernel, bbl., lb	.05½	nom.	.03½-......
Peanut oil, crude, tanks (mill), lb	.09½-......	.09½-......	.05½-......
Rapeseed oil, refined, bbl., gal	.45 - .46	.43 - .45	.38 - .40
Soya bean, tank, lb	.09 -......	.09 -......	.06 -......
Sulphur (olive foots), bbl., lb	.08¾-......	.08¾-......	.07½-......
Cod, Newfoundland, bbl., gal	.35 -......	.33 -......	nom.
Menhaden, light pressed, bbl., lb	.067-......	.069-......	.051-......
Crude, tanks (f.o.b. factory), gal	.30 -......	.30 -......	.20 -......
Grease, yellow, loose, lb	.06⅝-......	.06½-......	.03½-......
Oleo stearine, lb	.09½-......	.09½-......	.05½-......
Red oil, distilled, d.p. bbl., lb	.09½-......	.09½-......	.07 -......
Tallow, extra, loose, lb	.07½-......	.06½-......	.03½-......

CHEM. & MET.'S WEIGHTED PRICE INDEXES









Coal-Tar Products

	Current Price	Last Month	Last Year
Alpha-naphthol, crude, bbl., lb	$0.60 -$0.65	$0.60 -$0.65	$0.60 -$0.62
Refined, bbl., lb	.80 - .85	.80 - .85	.80 - .85
Alpha-naphthylamine, bbl., lb	.32 - .34	.32 - .34	.32 - .34
Aniline oil, drums, extra, lb	.14½- .15	.14½- .15	.14½- .15
Aniline salts, bbl., lb	.24 - .25	.24 - .25	.24 - .52
Bensaldehyde, U.S.P., dr., lb	1.10 - 1.25	1.10 - 1.25	1.10 - 1.25
Bensidine base, bbl., lb	.65 - .67	.65 - .67	.65 - .67
Bensoic acid, U.S.P., kgs, lb	.48 - .52	.48 - .52	.48 - .52
Bensyl chloride, tech., dr., lb	.30 - .35	.30 - .35	.30 - .35
Bensol, 90%, tanks, works, gal	.15 - .16	.15 - .16	20½- .21
Beta-naphthol, tech., drums, lb	.22 - .24	.22 - .24	.22 - .24
Cresol, U.S.P., dr., lb	.11 - .11½	.11 - .11½	.11- .11½
Cresylic acid, 97%, dr., wks., gal	.42 - .43	.42 - .43	.50 - .51
Diethylaniline, dr., lb	.55 - .58	.55 - .58	.55 - .58
Dinitrophenol, bbl., lb	.29 - .30	.29 - .30	.29 - .30
Dinitrotoluen, bbl., lb	.16 - .17	.16 - .17	.16 - .17
Dip oil, 25% dr., gal	.23 - .25	.23 - .25	.23 - .25
Diphenylamine, bbl., lb	.38 - .40	.38 - .40	.38 - .40
H-acid, bbl., lb	.65 - .70	.65 - .70	.65 - .70
Naphthalene, flake, bbl., lb	.05½- .06½	.05½- .06½	.06 - .07
Nitrobensene, dr., lb	.08½- .09	.08½- .09	.08½- .10
Para-nitraniline, bbl., lb	.51 - .55	.51 - .55	.51 - .55
Phenol, U.S.P., drums, lb	.14½- .15	.14½- .15	.14½- .15
Picric acid, bbl., lb	.30 - .40	.30 - .40	.30 - .40
Pyridine, dr., gal	1.10 - 1.15	1.10 - 1.15	.90 - .95
Resorcinal, tech., kegs, lb	.65 - .70	.65 - .70	.65 - .70
Salicylic acid, tech., bbl., lb	.40 - .42	.40 - .42	.40 - .42
Solvent naphtha, w.w., tanks, gal	.26 -......	.26 -......	.26 -......
Tolidine, bbl., lb	.88 - .90	.88 - .90	.88 - .90
Toluene, tanks, works, gal	.30 -......	.30 -......	.30 -......
Xylene, com., tanks, gal	.30 -......	.30 -......	.26 -......

Miscellaneous

	Current Price	Last Month	Last Year
Barytes, grd., white, bbl., ton	$22.00-$25.00	$22.00-$25.00	$22.00 $25.00
Casein, tech., bbl., lb	.12 - .14	.12½- .14	.12 - .13
China clay, dom., f.o.b. mine ton	8.00 -20.00	8.00 -20.00	8.00 -20.00
Dry colors:			
Carbon gas, black (wks.), lb	.04 - .20	.04 - .20	.04 - .20
Prussian blue, bbl., lb	.36½- .38	.36½- .38	.35½ .37
Ultramine blue, bbl., lb	.06 - .32	.06 - .32	.06 - .32
Chrome green, bbl., lb	.26 - .27	.26 - .27	.26 - .27
Carmine red, tins, lb	4.00 - 4.40	4.00 - 4.40	4.00 - 4.40
Para toner, lb	.80 - .85	.80 - .85	.80 - .85
Vermilion, English, bbl., lb	1.52 - 1.55	1.56 - 1.58	1.58 - 1.60
Chrome yellow, C. P., bbl., lb	.15 - .16	.15 - .15½	.15 - .15½
Feldspar, No. 1 (f.o.b. N.C.) ton	6.50 - 7.50	6.50 - 7.50	6.50 - 7.50
Graphite, Ceylon, lump, bbl., lb	.07 - .08½	.07 - .08½	.07 - .08½
Gum copal Congo, bags, lb	.09 - .10	.09 - .10	.06 - .08
Manila, bags, lb	.09 - .10	.09 - .10	.16 - .17
Damar, Batavia, cases, lb	.15½- .16	.15½- .16	.16 - .16½
Kauri No. 1 cases, lb	.20 - .25	.20 - .25	.45 - .48
Kieselguhr (f.o.b. N.Y.), ton	50.00 -55.00	50.00 -55.00	50.00 -55.00
Magnesite, calc, ton	50.00 -......	50.00 -......	40.00 -......
Pumice stone, lump, bbl., lb	.05 - .07	.05 - .08	.05 - .07
Imported, casks, lb	.03 - .40	.03 - .40	.03 - .35
Rosin, H., bbl	5.65 -......	5.70 -......	5.75 -......
Turpentine, gal	.50½-......	.52½-......	.52 -......
Shellac, orange, fine, bags, lb	.25 -......	.27 -......	.37 - .38
Bleached, bonedry, bags, lb	.21 - .22	.19 - .21	.35 - .36
T. N. bags, lb	.14 - .15	.13½- .14	.28 - .29
Soapstone (f.o.b. Vt.), bags, ton	10.00 -12.00	10.00 -12.00	10.00 -12.00
Talc, 200 mesh (f.o.b. Vt.), ton	8.00 - 8.50	8.00 - 8.50	8.00 - 8.50
300 mesh (f.o.b. Ga.), ton	7.50 -10.00	7.50 -10.00	7.50 -11.00
225 mesh (f.o.b. N.Y.), ton	13.75 -......	13.75 -......	13.75 -......

INDUSTRIAL NOTES

MICHIGAN PRODUCTS CORP., Michigan City, Ind., has appointed William B. Cooley as its Indiana representative with headquarters at 433 N. Capitol Ave., Indianapolis. Paul S. Menough has been appointed representative for Pennsylvania with offices in the Chamber of Commerce Bldg., Pittsburgh.

J. G. WHITE ENGINEERING CORP., New York, has moved its offices to 80 Broad St.

REPUBLIC STEEL CORP., Youngstown, Ohio has made Lee Wright its sales representative in the Utah territory with headquarters at 401 Atlas Bldg., Salt Lake City.

READ MACHINERY CO., INC., York, Pa., has placed Donald Loyhed in charge of its Cleveland office at 7500 Euclid Ave.

THE ELECTRIC STORAGE BATTERY CO., Philadelphia, has appointed William P. Roche manager of its Cleveland office to succeed Herbert F. Sauer who is now in charge of the Chicago branch.

WORTHINGTON PUMP AND MACHINERY CORP., Harrison, N. J., has elected to its board of directors, Albert C. Bruce, president of the United States Hoffman Machinery Corp.

THE BROWN INSTRUMENT CO., Philadelphia, and The Minneapolis-Honeywell Regulator Co., Minneapolis, have opened a joint office at 101 Marietta St., Atlanta. Wesley R. Moore is in charge with Leon L. Kuempel, sales engineer, Charles Kitzinger, service engineer, and J. A. Crawley, office manager.

GENERAL REFRACTORIES CO., Philadelphia, has appointed the Shadbolt and Boyd Co., Milwaukee, as dealer agents with the Broadway Mfg. Co., as new representatives in the Knoxville territory.

WILSON & BENNETT MFG. CO., Chicago has appointed C. Bennett, 223 Fourth Ave. N., Birmingham as representative in the Alabama territory.

COLE CHEMICAL CORP., has taken over the business of M. V. Cole Corp., New York, and has moved its operations to Long Island City.

THE ABRAHAMSON CORP., announces that Henry F. Sproull has become associated with it as representative in the Buffalo territory.

New CONSTRUCTION

Where Plants Are Being Built in Process Industries

	Current Projects: Proposed Work and Bids	Current Projects: Contracts Awarded	Cumulative 1935: Proposed Work and Bids	Cumulative 1935: Contracts Awarded
New England	....	$75,000	$839,000	$280,000
Middle Atlantic	$188,000	247,000	1,969,000	952,000
South	406,000	4,028,000	6,579,000	1,233,000
Middle West	1,003,000	4,578,000	7,646,000	5,780,000
West of Mississippi	63,000	6,000	4,614,000	3,265,000
Far West	....	....	1,436,000	5,500,000
Canada	262,000	1,070,000	5,595,000	70,000
Total	$1,922,000	$10,004,000	$28,678,000	$17,080,000

PROPOSED WORK BIDS ASKED

By-Products Plant—Superior Charcoal & By-Products Co. Ltd., Leonard Bartlett, Pres., London, Ont., Can., plans the construction of a plant. Estimated cost $50,000.

Chemical Plant—Merck & Co., 916 Parrish St., Philadelphia, Pa., plans to repair and alter its plant recently damaged by fire. Estimated cost to exceed $30,000.

Chemical Laboratory—State of Florida, Department of Agriculture, Tallahassee, Fla., plans the construction of a chemical laboratory and offices east of the State Capitol Building. Estimated cost $100,000.

Chemical Laboratory—J. A. Tumbler Laboratories, manufacturer of polishes, 423 South Hanover St., Baltimore, Md., plans repairs and alterations to its chemical laboratory. Estimated cost to exceed $30,000.

Creosoting Plant — Ontario Creosoting Co., Ltd., Bank of Hamilton Bldg., Toronto, Ont., Can., R. D. Prethie, Secy.-Mgr., plans the installation of a two cylinder pressure plant equipped to season timber by boiling under vacuum, each cylinder 6½ ft. diameter by 147 ft. long, at Port Arthur, Ont.

Distillery — Bond Distilling Co., c/o H. A. Bond, Green Bay, Wis., is having preliminary plans prepared by Carl J. Kiefer, Engr., Schmidt Bldg., Cincinnati, O., for the construction of a distillery, including equipment. Estimated cost $300,000.

Distillery — Cedar Valley Distilling Co., Wooster, O., contemplates the construction of a storage and distribution plant. W. G. Lanphear & Sons, 11 Court St., Buffalo, Archt. and Engr. Estimated cost $40,000.

Distillery—Coffey Distilling Co., Fisherville, Ky., plans to construct a still, fermentation building, boiler room and storage room. Walter E. Wagner, Breslin Bldg., Louisville Ky., Arch. and Engr. Estimated cost will exceed $28,000

Distillery—Parker Pure Rye Co., New Brunswick, N. J., has acquired the plant of the Cadgene Piece Dye Works and will alter same into a distillery. Estimated cost $100,000.

Distillery—Pattison Bros. Kentucky Bourbon Distillery, 325 Lafayette Ave., Cincinnati, O., contemplates the construction of a distillery at Ludlow, Ky. Estimated cost to exceed $28,000.

Distillery — St. Lawrence Co-operative Distillery Co., St. Lawrence, Wis., plans the construction of a distillery, winery, etc. Estimated cost, including equipment, $28,000.

Glass Factory—Dominion Glass Co., Ltd., Chapple St., Hamilton, Ont., Can., contemplates the construction of a 1 story, 100x550 ft. addition to its plant to be used mostly for storage. Estimated cost $100,000.

Glass Factory—Pittsburgh Plate Glass Co., 235 East Pittsburg Ave., Milwaukee, Wis., contemplates the construction of a glass factory. Estimated cost $300,000, approximately $160,000 of which will be used for buildings and $140,000 for machinery and new equipment.

Lime Plant—Vandalia Chemical Co., Vandalia, N. Y., or c/o Union Charcoal & Chemical Co., Olean, N. Y., contemplates the construction of a lime and mixing plant. Estimated cost, including equipment, $28,000. Maturity indefinite.

Gasoline Refinery — C. B. Bunte, Eureka, Harris Co., Tex., plans to construct a gasoline extracting plant. Estimated cost $35,000 or more.

Gasoline Refinery — Corporation, c/o Judge E. C. Couch, Sullivan City, Tex., plans to construct a gasoline refinery to have a capacity of 1,500 bbls.

Paper Mill—Cromwell Paper Co., 4821 South Whipple St., Chicago, Ill., is having plans prepared by A. Epstein, Archt., 2001 West Pershing Rd., Chicago, for the construction of a paper mill. Estimated cost $100,000.

Rubber Factory—Balta Rubber Co. of Canada, Brampton, Ont., Can., contemplates the construction of a factory for the manufacture of hard rubber products.

Sugar Refineries — Michigan Sugar Refining Co., 2nd National Bank, Saginaw, Mich., plans to modernize and repair its beet sugar refineries at Owosso, Saginaw, Crosswell, Bay City, Sebewaing, Lansing and Cairo, Mich. Estimated cost exceeds $200,000.

Factory — Ohio Bronze Powder Co., G. F. Glass, Pres., 1120 East 152nd St., Cleveland, Ohio, is having preliminary plans prepared by Richards & Richarson, Archts., 22 South St. Clair Ave., Painesville, O., for the construction of a factory at Painesville. Estimated cost $35,000.

Shellac Factory—Novo-Broom & Mop Supplies, Ltd., Montreal, Que., Can., plans the construction of a shellac manufacturing factory.

Plant—Bell & Son, Ltd., Liverpool, England, plans the construction of a plant for the manufacture of veterinary medicines and mineral food for live stock at Calgary, Alta., Can.

CONTRACTS AWARDED

By-Products Coke Plant — Ford Motor Co., Dearborn, Mich., let contract for by-products coke plant including two batteries of 61 ovens each, as adjunct to steel plant, to Koppers Construction Co., Koppers Bldg., Pittsburgh, Pa. Estimated cost $4,000,000.

Chemical Plant—Merck & Co., Rahway, N. J., awarded contract for the construction of a plant to Walter Kidde Construction Co., 140 Cedar St., New York, N. Y.

Chemical Factory — Monsanto Chemical Co., 1700 South 2nd St., St. Louis, Mo., awarded contract for 1 story, 60x69 ft. brick factory addition in rear of 1900-10 South 2nd St., to Brockmeyer-Bohle, Inc., 445 Missouri Theatre Bldg., St. Louis. Estimated cost $6,000.

Distillery—Trenton Valley Distilling Co., Trenton, Mich., awarded contract for distribution and bottling plant to Culbertson & Kelly, 872 West Milwaukee, St., Milwaukee, Wis. Estimated cost $50,000.

Factory—Lumnite Products Corp., Salamanca, N. Y., awarded contract for factory to Benz Engineering Co., 33 Main St., Salamanca. Estimated cost $28,500.

Factory — Raybestos-Manhattan, Inc., 1427 Railroad Ave., Bridgeport, Conn., awarded contract for factory at Stratford, Conn., to Edwin Moss & Son, Inc., Union Ave., Bridgeport, Conn. Estimated cost $35,000.

Glass Factory—Owens-Illinois Glass Co., 965 Wall St., Toledo, O., will construct a factory at Bridgeton, N. J. Work will be done under separate contracts. Estimated cost including equipment $28,000.

Ink Factory—Intag Co., 2528 West 48th Pl., Chicago, Ill., let contract for addition to factory to A. S. Low., 510 North Dearborn St., Chicago. Estimated cost including equipment $100,000.

Laboratory — Department of Agriculture, Washington, D. C., awarded contract for main laboratory building, to Lacchi Construction Co., Munsey St., Baltimore, Md., $163,016.

Mineral Crushing Plant — Standard Mineral Co., Hemp, N. C., and 230 Park Ave., New York, N. Y., has awarded separate contracts for the construction of a mineral crushing plant at Hemp, to have a daily capacity of 100 tons.

Paper Mill—Garden City Paper Co., Lincoln Ave., Merritton, Ont., Can., awarded contract paper mill to Newman Bros., 127 St. Paul St., St. Catherines, Ont. Estimated cost $70,000.

Paper Mill—Union Bag & Paper Co., Woolworth Bldg., New York, N. Y., awarded contract for paper mill, warehouse and railroad facilities, at Savannah, Ga., to Merritt, Chapman & Scott Corp., 17 Battery Pl., New York. Estimated cost $4,000,000.

Rayon Factory—Franklin Rayon Corp., 86 Crary St., Providence, R. I., awarded contract 3 story addition to rayon factory to A. F. Smiley Construction Co., 202 Oak Hall Bldg., Providence. Estimated cost exceeds $40,000.

Sugar Refinery—British Columbia Sugar Refining Co., Ltd., foot of Rogers St., Vancouver, B. C., will construct a sugar refinery at Picture Butte, Alta., Can. Work will be done under supervision of Dominion Construction Co., Ltd., 509 Richards St., Vancouver, C. Bentall, Manager and Chief Engineer. Estimated cost $1,000,000.

Storage Tanks—U. S. Industrial Alcohol Co., Curtis Bay, Baltimore, Md., awarded contract for 15 storage tanks to Ingalls Iron Works, 1 East 42nd St., New York, N. Y.

Warehouse—Seagrams Distillers' Corporation, Lawrenceburg, Ind., awarded contract for warehouse to J. & E. Warm Co., Ingalls Bldg., Cincinnati, O. Estimated cost $400,000.

New Plants and Products in World Chemical Industry

NEW CHEMICALS produced commercially for the first time and the number of countries extending their activities into lines of chemical production new to them, probably exceeded all records in 1934, according to a world survey of the chemical industry, recently completed by the Bureau of Foreign and Domestic Commerce.

In the Far East, the Mitsubishi interests in Japan started the manufacture of sulphuric acid, dyes, and inorganic chemicals. Japan Iodine Co. started a plant for a varied line of chemicals. The Sumitomo Chemical Industry Co., also in Japan, built a plant for manufacture of synthetic methanol. Other new Japanese plants included one for butanol and acetone from waste molasses, a benzol plant, and plants for potassium carbonate, ammonium chloride, anhydrous acetic acid, and plastics.

In Shanghai, a new liquid-ammonia and nitric acid plant was expected to be in operation in 1935 as well as an alcohol plant. Other new Chinese plants made oxygen, acetylene, sulphuric acid, caustic soda, and bleaching powder.

Two factories were under construction in British India; one to produce synthetic phenolic resin and the other to make carbon dioxide.

No less than 50 new chemical plants went into operation in Europe. At least one plant for each of the items named was established in Austria to manufacture the following products: printing inks, lithopone, glycerin, pyroxylin plastics, synthetic resin, carbon dioxide, filtering materials, pharmaceuticals, insulin, and electrometallurgical and electrochemical products.

A new acetylene factory commenced operations in Belgium to replace the plant destroyed by fire in 1931. Plans were also made to produce the rare gases krypton and xenon. The largest Belgian zinc producer commenced the production of copper sulphate, thallium sulphate, and thallium chloride, and increased its output of sulphuric acid.

In December the new carbon-black plant in Prague was operating at full capacity, with a total annual output of approximately 600 metric tons. The largest producer of printing inks in Czechoslovakia started operations in its new plant, also located in Prague, prior to June 1934. The leading Czechoslovak producer of shoes commenced the erection of a chemical plant to manufacture principally sodium sulphite and bisulphite.

In France a new nitrate of lime plant was opened and in Germany despite government restrictions, new plants were reported for carbon dioxide, tar distillation and oxygen and hydrogen. Two new units in the Ruhr also started extraction of sulphur from coke-oven gas.

In Great Britain new plants included two for carbon dioxide, a coal-distillation works, a zinc-distillation works, two paint factories, and a plant for granular superphosphate.

Denmark reported a new plant at Koge to manufacture dyestuffs, chrome tanning agents, and a variety of synthetic perfumes.

In Poland, manufacture of lanoline, not hitherto made in the country, was commenced, and the Polish State Powder Factory began the manufacture of sulphur chloride. The state nitrogen-fixation factory at Moscice began in 1933-34 the manufacture of oxygen, nitric acid, bleaching powder, caustic soda, and ammonium nitrate, and the state factory at Chorzow was for the first time producing oxygen, ammonium nitrate, sodium nitrate, refined ammonium chloride, ammonium carbonate, potassium nitrate, and commercial calcium carbide.

Soviet Russian developments have been numerous the past few years, but the plants known to have gone into operation in 1934 were the first plant in the country for the manufacture of synthetic methanol and three wood-distillation plants; while unofficially two carbon-black plants with four units each were reported; also plants for the manufacture of calcium carbide, copper sulphate, natural dyestuffs, acetone and butanol from corn, and a sulphur plant. Other developments included expanding plantings of tung trees and extension of synthetic dyestuffs, with production of new dyes and intermediates.

A new factory commenced the manufacture of solid carbon dioxide in Yugoslavia.

In accordance with the law requiring government authorization for the erection of new plants in Italy a number of new companies were granted permission to build plants for production of hydrocyanic acid, potassium cyanide, sodium cyanide, urea-formaldehyde resins, electrolytic hydrogen peroxide, cyanamide, barium chloride and barium carbonate, potassium permanganate, solid carbon dioxide, hydrochloric acid and bleaching powder, xylene, nitrocellulose, acetoacetic ether, and aromatic amines.

At least 13 plants, located in almost as many different Provinces, were reported as having been completed or nearly completed in Canada during the past year. Most of these were for the manufacture of industrial chemicals, imported for the most part from the United States, and included two calcium-chloride plants, an alkali plant to make caustic soda and chlorine, one establishment each for the manufacture of sodium sulphate, alum, zinc dust, and trisodium phosphate, the first plant in Canada for the manufacture of electrolytic hydrogen peroxide from ammonium persulphate, a plant to produce sulphur from pyrites by the chlorinization process, an explosives factory, a printing ink factory, and a new branch factory of an American corporation for the manufacture of cosmetics.

In South America, La Sulfurica built a new plant in the Argentine, with annual capacity of 2,400 tons of copper sulphate. A caustic soda plant in Brazil was expected to be completed early in 1935 with a capacity of 2,500 tons a year and 700 tons of bleaching powder, 300 tons of muriatic acid, and 1,200 tons of liquid chlorine.

New Foreign Products

Germany brought out several new commodities, including "Dipenten," a varnish thinner made from turpentine diluted with petroleum ether; "Weichmachungsmittel 90" (Plasticizer 90), a lacquer material; "Parabernol," a liquid from waste and scrap amber to be used instead of shellac; "Acronal," new vinyl compounds; a rustproofing coating, a new fertilizer, ammonia-lime; liquid-oxygen explosives; and a carbon suitable for use in rubber manufacture.

In England new products included granular superphosphate; a motor fuel; "Cardice"; and "Dec," a plastic material. Other European products were "Supertomasyna," a phosphate from Poland; "Nex," an insecticide; and "Sabeol," a disinfectant (claimed to be a substitute for iodine) derived from bergamot oil from Italy; and magnesium-calcium nitrate, a fertilizer introduced on the French market.

New commodities of Japanese origin were "Yedocol," a vegetable granular carbon; titanium stearite, a colloid of titanium and stearine; and a pyroxylin plastic.

The Near East and Africa likewise contributed new products; Palestine introduced a new cleansing fluid and disinfectant called "Tropoclin"; Kenya, a water softener and boiler feed compound, "Tannoda," and a refrigerant, "Carrene" (trichloromono-fluoromethane); and from the Union of South Africa, a poison spray for locust control, which it was claimed, would rid the country of locusts for three years.